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GENERAL DESCRIPTION OF GREAT LAKES/ST. LAWRENCE SEAWAY PHYSICAL SYSTEM

TASK 6 - Report of Great Lakes/St. Lawrence Seaway Regional Transportation Studies

Prime Contract DACW 35-80-C0060

September 1981

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Submitted to

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straits of Mackinac	visibility limitations	capacity
St. Clair-Detroit River	harbors	lock size
Lake Erie	connecting channels	channel depths

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

- This report provides a general description of the Great Lakes/St. Lawrence Seaway physical system and its subsystems. The report discusses the principal component harbors, locks and connecting channels and their restrictions, economic life, planned improvements and long term capacity limitations.

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6. GENERAL DESCRIPTION OF THE GREAT LAKES/ ST. LAWRENCE SEAWAY PHYSICAL SYSTEM

6.1 Introduction

The Great Lakes/Saint Lawrence Seaway System (GL/SLS) provides a shipping link between the deep water of the Atlantic Ocean and ports 2400 miles inland on the American continent (1). With the current requirements for overseas shipping of bulk products such as coal and grain, it is significant to note that the Great Lakes ports of Buffalo, Cleveland, Toledo, and Detroit are closer to the ports of Northern Europe and the United Kingdom than are the ports along the U.S. Atlantic Coast. For example, Detroit is 236 miles closer to Liverpool than is Baltimore. In shipping products out of Detroit, the savings is not only these 236 miles, but in addition a savings of 604 miles of overland travel that would be required between Detroit and Baltimore. The total savings is 840 miles, which is nearly 20% of the total trip (1).

From the Atlantic Ocean to Duluth, the GL/SLS covers approximately 2400 nautical miles. This includes 1000 statute miles down the St. Lawrence River, 1350 miles over the Great Lakes, and 400 miles in connecting channels. In that distance there are sixteen sets of locks that lift ships from sea level to an elevation of 600 feet in Lake Superior. Figure 6.1 is a schematic cross-section of the Seaway and the lock system. Figure 6.2 shows the area covered by the system.

The capacity of any navigation system including the Great Lakes/St. Lawrence Seaway System is determined by the system's limiting or constraining element; the element which has the slowest processing time. In very general terms, the GL/SLS system can be thought of as a series of locks, connecting channels, and harbors. The complexity inherent in the three lock systems, the five connecting channels, and over forty harbors becomes even more significant when the numerous trade routes between the various harbors for inland traffic and for the ocean trade are also considered. Generally, for navigation systems equipped with locks, the traffic capacity, defined either in terms of annual tonnage or annual vessel transits, is constrained by the locks. Prior capacity studies of the GL/SLS system have indeed shown the locks to be the constraining element of this system. As the annual tonnage shipped on the GL/SLS navigation system continues to increase in the future, the demand for service at the locks will increase accordingly, and as the capacity limits of the system are approached, vessels will begin to

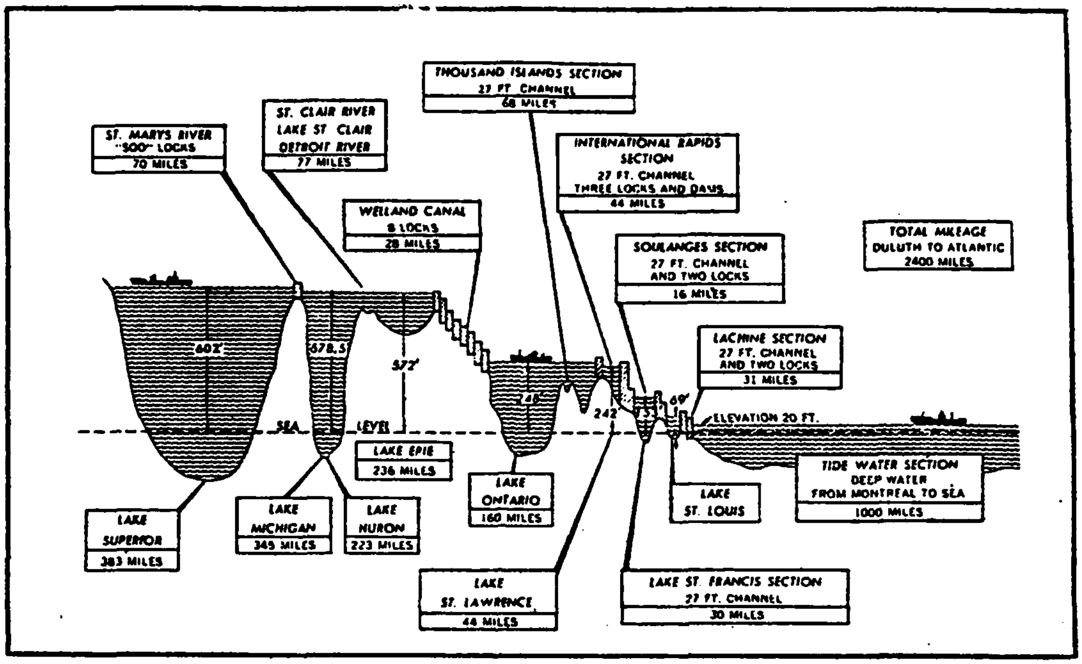


FIGURE 6.1 PROFILE OF GREAT LAKES-ST. LAWRENCE NAVIGATION SYSTEM

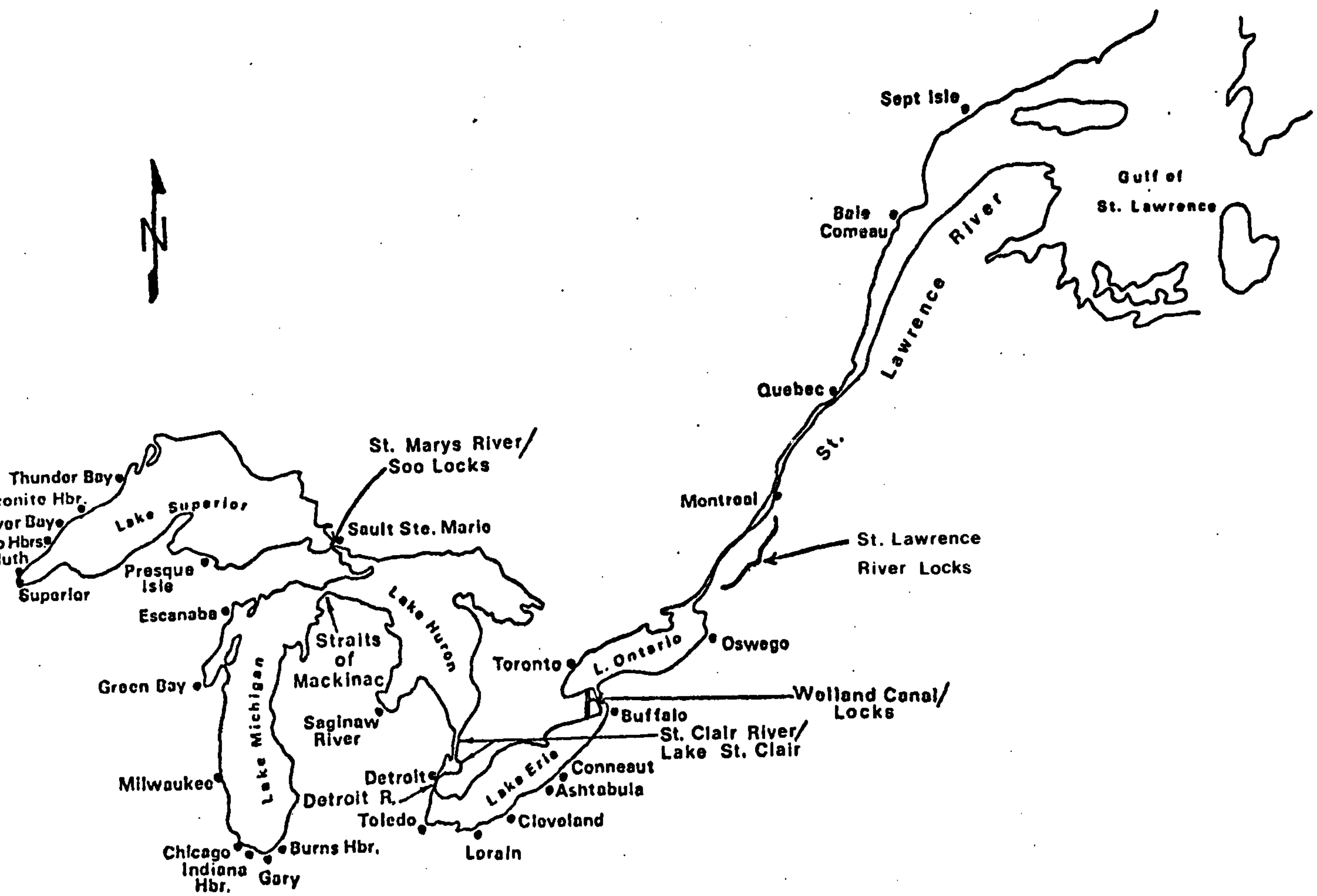


FIGURE 6.2 THE GREAT LAKES - ST. LAWRENCE SEAWAY SYSTEM

experience long waiting times and long vessel queues at the locks. The resulting inability of the system to effectively service its customers would obviously be reflected in a decrease in the popularity and use of the system, with an adverse impact on the economic growth of the entire nineteen state region served by the system.

Any transportation system interested in serving its customers over the long term must plan to provide an expanded capacity when the need for such capacity is required by the system's users. For a simple system having one major constraining component, the removal of the constraint at that one point removes the system constraint. For a more complex system, such as the GL/SLS navigation system, the multiplicity of locks, connecting channels, and harbors presents a more challenging assignment to the planners addressing the removal of system capacity constraints over the long term. An analysis of the entire system is required to ensure that removal of a constraint at one feature or location does not simply result in movement of the constraint to another feature or location with relatively little, if any, improvement in overall system capacity.

With such considerations in mind, the North Central Division of the U.S. Army Corps of Engineers initiated a study entitled, "Great Lakes/St. Lawrence Seaway Regional Transportation Studies," having as its primary objective the development of a sound documented working tool for use in analyzing GL/SLS regional transportation improvement alternatives. This report documents the work of Task 6 of this program, which requires a description of the GL/SLS physical system in terms of locks, connecting channels, and harbors. The work of this task includes not only the general background information on the physical characteristics of the system required as the first step for any study of system capacity, but also includes an on-scene investigation of current problems, current improvement programs, and planned near-term and long-term improvement programs. In the case of the latter information, the 50-year planning framework for this study is such that it is well beyond the short-term period for which any formal improvement plans have been programmed.

The purpose of this section of the report is to present a clear picture of the physical constraints to vessel size on the GL/SLS system, the possible restrictions to the amount of tonnage transported, and possible restrictions to future expansion of the system. This section also presents a general description of current system capability as well as an assessment of the potential for increasing that capability.

The description of the complete Great Lakes/St. Lawrence Seaway System is organized in terms of its principal components:

- Locks
- Connecting Channels
- Harbors.

Locks and connecting channels are described together when the locks are on the channels. Channels are described from the upper end of the system at Lake Superior, proceeding outbound to the Atlantic Ocean. The channels are locks included in the physical description are:

- St. Marys River including Soo Locks
- Straits of Mackinac
- St. Clair - Detroit River System
- Welland Canal including Locks
- St. Lawrence River including Locks.

The description of locks and channels includes constraints to present vessel size. These constraints include channel dimensions, lock sizes, and bridge clearances. The characteristics of some channel turns also restrict vessel size. Other constraints to the tonnage transported include speed limits, average water levels, short term fluctuations in water levels, and low visibility. Submarine cables, pipelines, and tunnels are noted because they are restrictive to channel expansion in terms of the cost to move or replace these facilities.

Table 6.1 shows the harbors specified to be included in this analysis. The description of each harbor includes actual and authorized draft, vessel restrictions, harbor facilities, length of the navigation season, authority for maintenance, and planned harbor developments. The description of each harbor is presented on a separate sheet arranged in the order shown in Table 6.1.

6.2 General Description of Connecting Channels

Table 6.2 summarizes channel dimensions and restrictions to navigation on the connecting channels. Note that the column

TABLE 6.1 U.S. HARBORS IN THE GREAT LAKES/ ST. LAWRENCE SEAWAY SYSTEM INCLUDED IN THE STUDY

LAKE SUPERIOR

Two Harbors, MN
Duluth-Superior, MN-WI
Presque Isle, MI
Marquette, MI
Taconite, MN
Silver Bay, MN
Ashland, WI

LAKE MICHIGAN

Green Bay, WI
Milwaukee, WI
Chicago, IL
Calumet Harbor, IN-IL,
  Lake Calumet
Indiana Harbor, IN
Burns Waterway, IN
Muskegon, MI
Gary, IN
Escanaba, MI
Grand Haven, MI
Ludington, MI
Buffington, IN
Port Inland, MI
Port Washington, WI

LAKE HURON

Saginaw, MI
St. Clair River, MI,
Port of Detroit, MI
  Detroit Harbor, Rouge
  River, Ecorse, Wyandotte,
  Riverview
Alpena, MI
Stoneport, MI
Drummond Island, MI
Port Dolomite, MI

LAKE ERIE

Toledo, OH
Sandusky, OH
Huron, OH
Lorain, OH
Cleveland, OH
Ashtabula, OH
Conneaut, OH
Erie, PA
Port of Buffalo, NY
  Niagara River, Buffalo
  River
Monroe, MI
Fairport, OH
Marblehead, OH

LAKE ONTARIO

Oswego, NY
Rochester, NY
Ogdensburg, NY

TABLE 6.2 GL/SLS CONNECTING CHANNELS - PHYSICAL DESCRIPTION (27)

CHANNEL	CONTROLLING DEPTH (ft)	LENGTH (miles)	GENERAL CHANNEL WIDTH (ft)	FALL (ft)	RESTRICTIVE WIDTH[1] (ft)
St. Marys River	27	63-75	300-1500	22	75, 105[2]
Straits of Mackinac	30	0.8	1250	0	NA
St. Clair River	27	46	700-1400	--	600[3]
Lake St. Clair	27.5	17	700-800	8	NA
Detroit River	27.5	32	300-1260	--	100
Welland Canal[5]	27	27	192-350	326	76[4]
St. Lawrence River	27	189	225-600	226	76[4]

NOTES:

1. Lock widths show maximum ship size allowed.

2. 75 feet restrictive width for the MacArthur, Sabin, and Davis Locks; 105 feet restrictive width for the Poe Lock.

3. Width restrictions at the Blue Water Bridge.

4. Lock restrictions.

5. A 4.5 mile section of the reach between Locks 7 and 8 is restricted to one-way navigation. A phased widening program will reduce the length of restricted channel to 3.0 miles for the 1982 season. The effect of the one-way restriction on lock capacity at this lock subsystem should be minimal after widening.

marked "General Channel Width" is the width of the open channel not including structures such as locks. The decrease in width that results from these structures is included in the column headed "Restrictive Width".

Figure 6.3 shows the maximum allowable cross-section for vessels transiting the Welland Canal and the St. Lawrence River Locks. This generalized sketch applies to any bascule bridge in the system. No vessel may have an object protruding beyond its hull or protruding beyond the lock wall up to a height of 65.6 feet above the waterline when the vessel is alongside the lock wall. These restrictions are based on vessels with a maximum allowable beam of 76 feet. Special permission to transit may be granted to vessels with less beam and protrusions beyond the limits of the diagram. Ships built in the Great Lakes with a wider than authorized beam may be granted permission for a single transit out into the ocean.

Published speed limits are restrictive in some downbound channels where the current velocity is so high that the vessel must overspeed to maintain adequate steerageway. Specific speed limits are shown with the detailed description of each channel.

Connecting channels are maintained at the depth authorized by law, which is called the "project depth". The actual depth of water in the channel varies because of daily and seasonal weather conditions plus silting caused by channel flow. Seasonally, the depth of water in the channels is affected by the water level in the lakes. The average elevation of the lake surfaces varies from year to year and over longer periods of time, typically a decade or more. These differences are basically caused by the amount of precipitation and run-off that occur during the cycle. During any given year, the water surface is typically lowest during the winter months and highest during the summer months. The Corps of Engineers has gage stations that continuously record water levels. The Detroit District of the Corps publishes these records on the 5th and 20th of each month in a document called the "Great Lakes and Connecting Channels Water Levels and Depths," NCE Form 11 (9). This bi-monthly flyer shows the average water levels for that date, the existing levels, and the expected levels for the next reporting date. These water levels are shown for each of the Great Lakes, the St. Lawrence River, the Detroit River, the St. Clair River, and the St. Marys River. Mariners are cautioned on these reports that the reported water levels are those that occur when the water surface elevation is not disturbed by wind and/or other causes. Short term variations in water level can occur in a

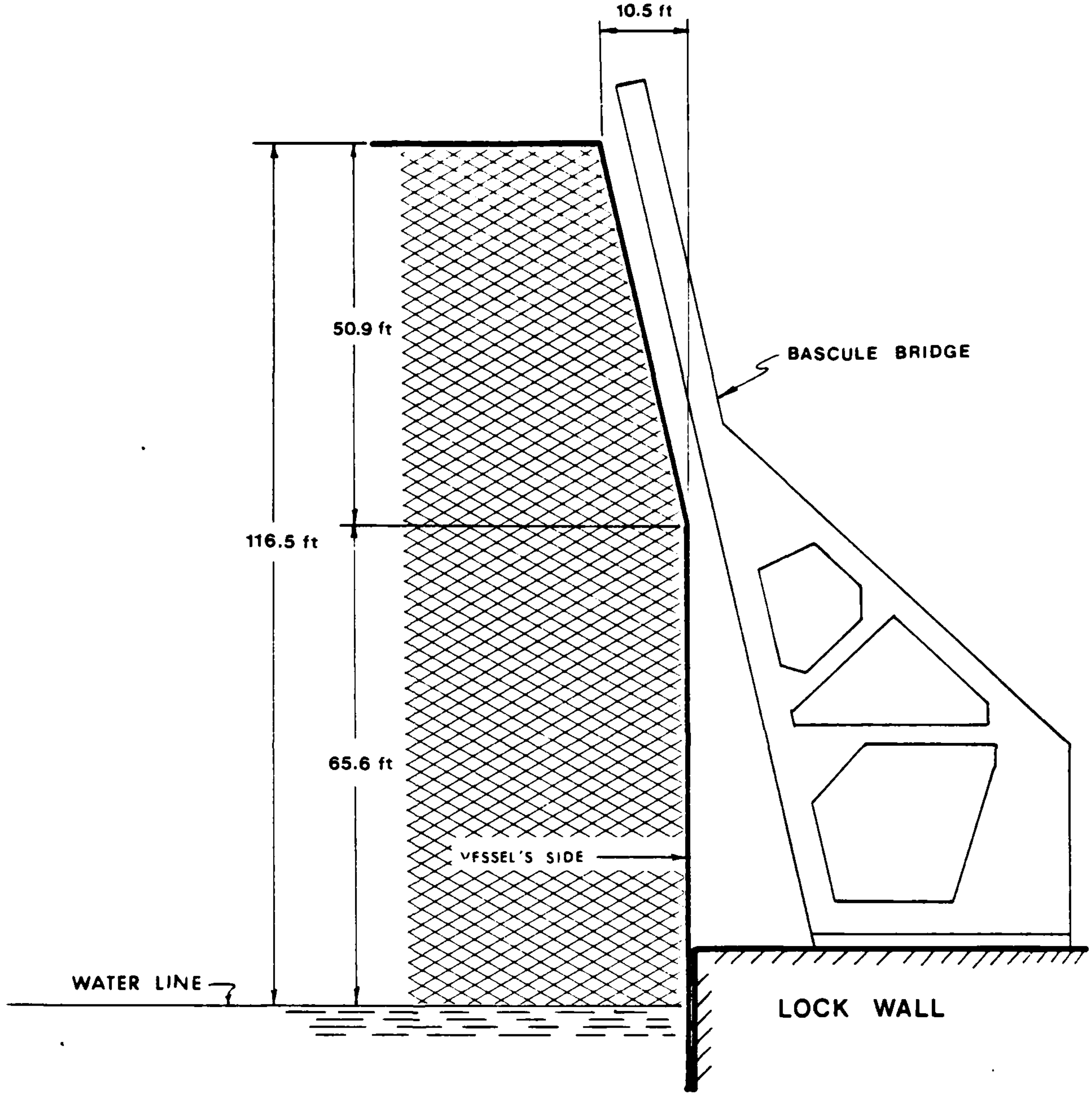


FIGURE 6.3 MAXIMUM ALLOWABLE CROSS-SECTION FOR VESSELS TRANSITING THE WELLAND CANAL AND THE ST. LAWRENCE RIVER LOCKS. This sketch shows the standard clearance for a bascule bridge in these two locks systems (8).

matter of hours. For example, low barometric pressure can cause channel depth to increase appreciably over a short period of time. Strong winds from a constant direction can either reduce or increase channel depth in a short time. The differences in depth caused by the wind are generally apparent at the ends of the lake. Table 6.3 shows both the average water level differences and the possible fluctuations that can occur in the connecting channels over short periods of time. Mariners are also reminded that the reports are of water levels, not channel depth. Channel depth may be restricted by silting or other obstructions.

The entire seaway system is constructed to permit a maximum draft of 25.5 feet when the water level is at low water datum (LWD). West of the Welland Canal, each ship's Master is responsible for determining the safe draft for his vessel based on the recorded maneuvering characteristics of his ship (10). Safe maneuvering draft is specified in the ship's design documents. The Master maintains a safe clearance with the bottom based on these records. As an aid in making this decision, the Lake Carriers' Association publishes recommended draft for the St. Marys River, the St. Clair River, and the Detroit River bimonthly. Figure 6.4 shows the recommended draft for these Great Lakes channels for the year 1979. These seasonal variations in recommended draft are typical of those that occur over any year.

In the St. Lawrence Seaway, the draft is limited by the locks in the Welland Canal and the St. Lawrence River. In this area the Canadian St. Lawrence Seaway Authority and the U.S. St. Lawrence Seaway Development Corporation (SLSDC) permit a draft of 26 feet. This draft is mandatory and is checked as the ships go through the locks (11).

6.3 St. Marys River Including Soo Locks

The St. Marys River connects Lake Superior to Lake Huron and contains the Soo Locks. Flowing southeasterly from Lake Superior at Point Iroquois, the river follows several channels on its way to Lake Huron. The outflow of Lake Superior, which was originally controlled by a rock ledge at the head of the river, is now regulated by the locks, compensating works, and powerhouses. Figure 6.5 shows the St. Marys River and notes significant points along the channel.

6.3.1 Physical Characteristics and Vessel Constraints of the Soo Locks

The Soo Locks are located at Sault Ste. Marie, Michigan. Before the Navigation Season Extension program started, the Soo

TABLE 6.3 WATER FLUCTUATIONS (4)

RIVER OR CHANNEL	MONTHLY MEAN DIFFERENCE (ft)	SHORT-TERM CHANGES (ft)
St. Marys River	±1	± 5 in 3 hrs, Barometric pressure
St. Clair River	±1	± 2 short-term, wind
Lake St. Clair		± 1 in several hours
Detroit River (Lower Section)	±2	± 6 in 8 hrs, wind
St. Lawrence River	Constant	± 2 short-term, wind

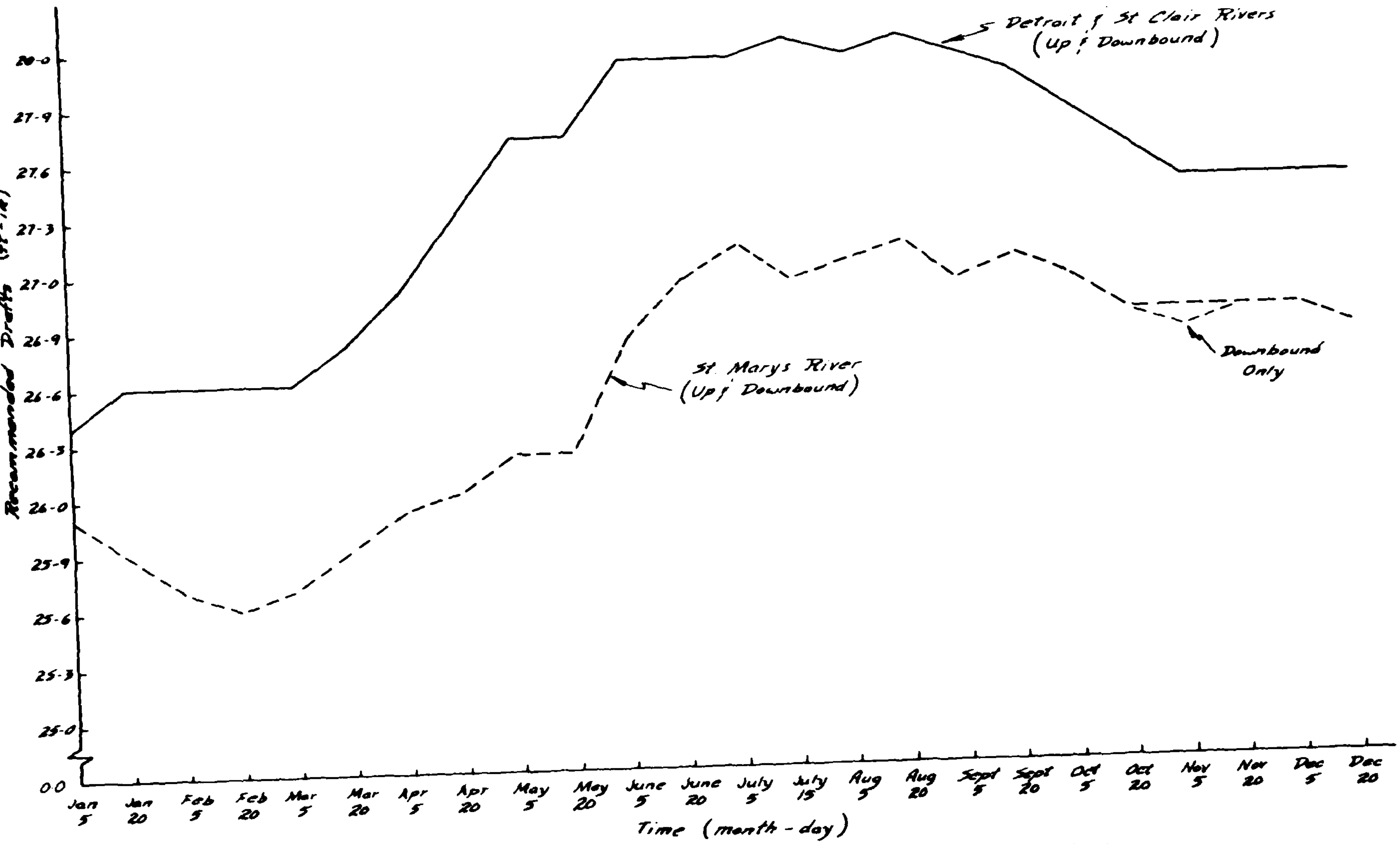


FIGURE 6.4 RECOMMENDED DRAFTS FOR GREAT LAKES CHANNELS - 1979 (12)

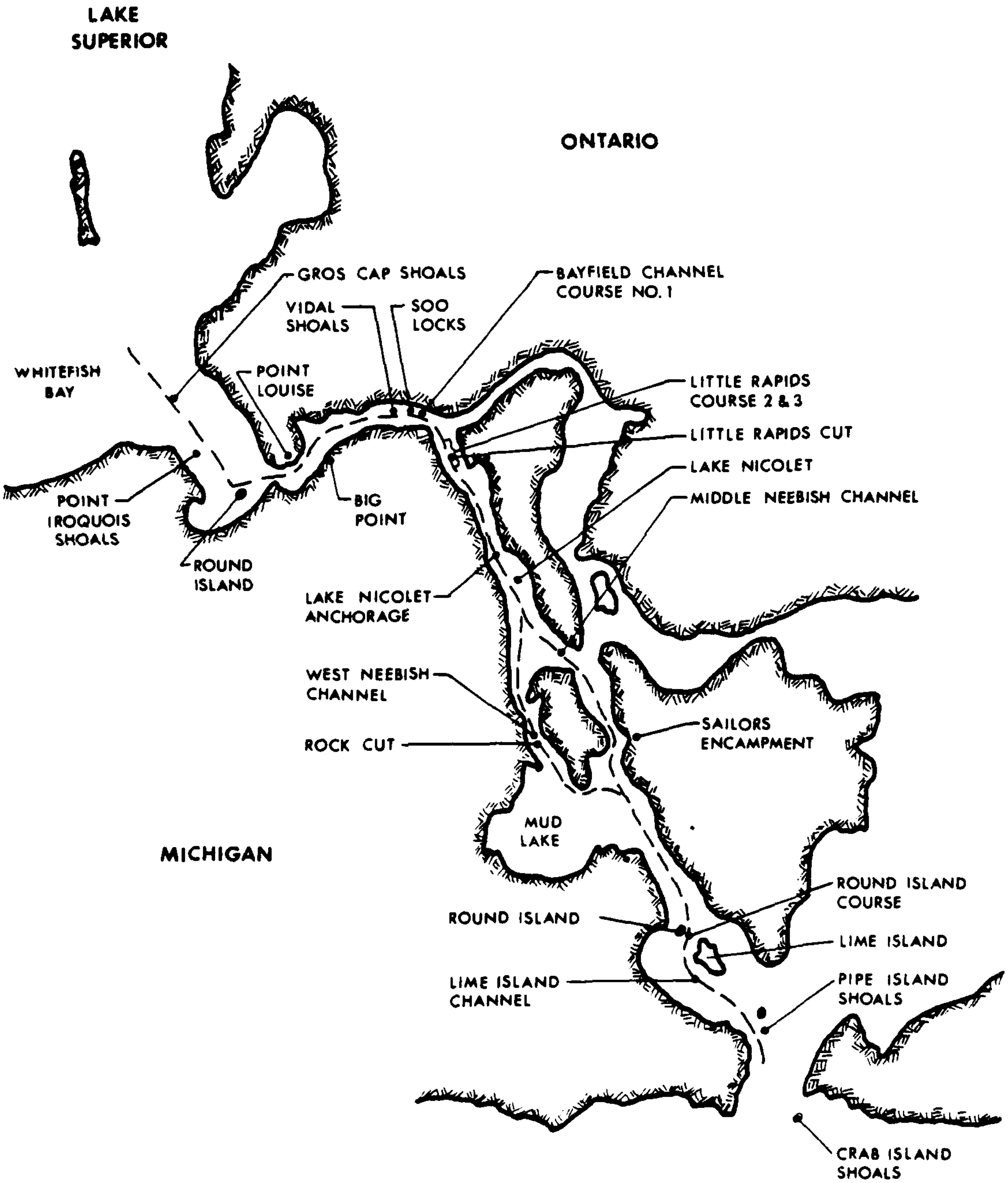


FIGURE 6.5 ST. MARYS RIVER CHANNEL

Locks were operated for approximately nine months each year from early April through late December. During the Season Extension Demonstration Program the Soo Locks were kept open into February for the first three years (1972 to 1974) and for 12 months for the remaining years of 1975 through 1978 (13). The closing date for the 1979-80 season was 15 January 1980, and for the 1980-81 season, operations were halted on 31 December 1980.

The Soo Lock system consists of four parallel locks--the MacArthur, Poe, Davis, and Sabin Locks--as shown in Figure 6.6. Each lock has its own pier that can accommodate two or three ships in each queue. In addition to the four United States locks, an older lock is located on the Canadian side of the St. Marys River. Although this lock is small and shallow, it does relieve congestion at the American locks by handling passenger vessels, pleasure craft, and other small ships carrying cargo. Because these vessels carry a small amount of cargo, the Canadian lock has been excluded from the analysis of the Soo Lock capacity.

Currently, the MacArthur Lock handles most of the downbound loaded ships with an overall length of up to 730 feet and a beam of 75 feet, but can accommodate ships up to 767 feet in length with special locking procedures. The Poe Lock can handle ships up to 1100 feet in length with a beam of 105 feet, but currently handles mostly "1000 footers" and all vessels that the MacArthur Lock cannot service. The Sabin and Davis Locks are identical in size and handle most of the ballasted upbound ships having a beam of up to 75 feet and length of up to 826 feet. Because of the shallow depth of both the Sabin and Davis Locks, the number of vessels using these locks has decreased as vessels have either been retired or phased-out of the Great Lakes fleets. As a result, only the Sabin or Davis Lock is usually operated unless there is sufficient demand to warrant the operation of both locks. Table 6.4 shows the dimensions of the Soo Locks and ship size restrictions.

6.3.2 Locks Maintenance Problems

The status of the maintenance programs for the Soo Locks was determined through personal interviews with Corps of Engineers operating personnel at Sault Ste. Marie, Michigan (6). These interviews revealed that the locks are basically in a good state of repair. Historically, there has been adequate time to perform both preventative and corrective maintenance during the time the locks are closed in the winter. Since all four locks are in parallel, some maintenance can also be performed during the navigation season by shutting down a single lock in slack

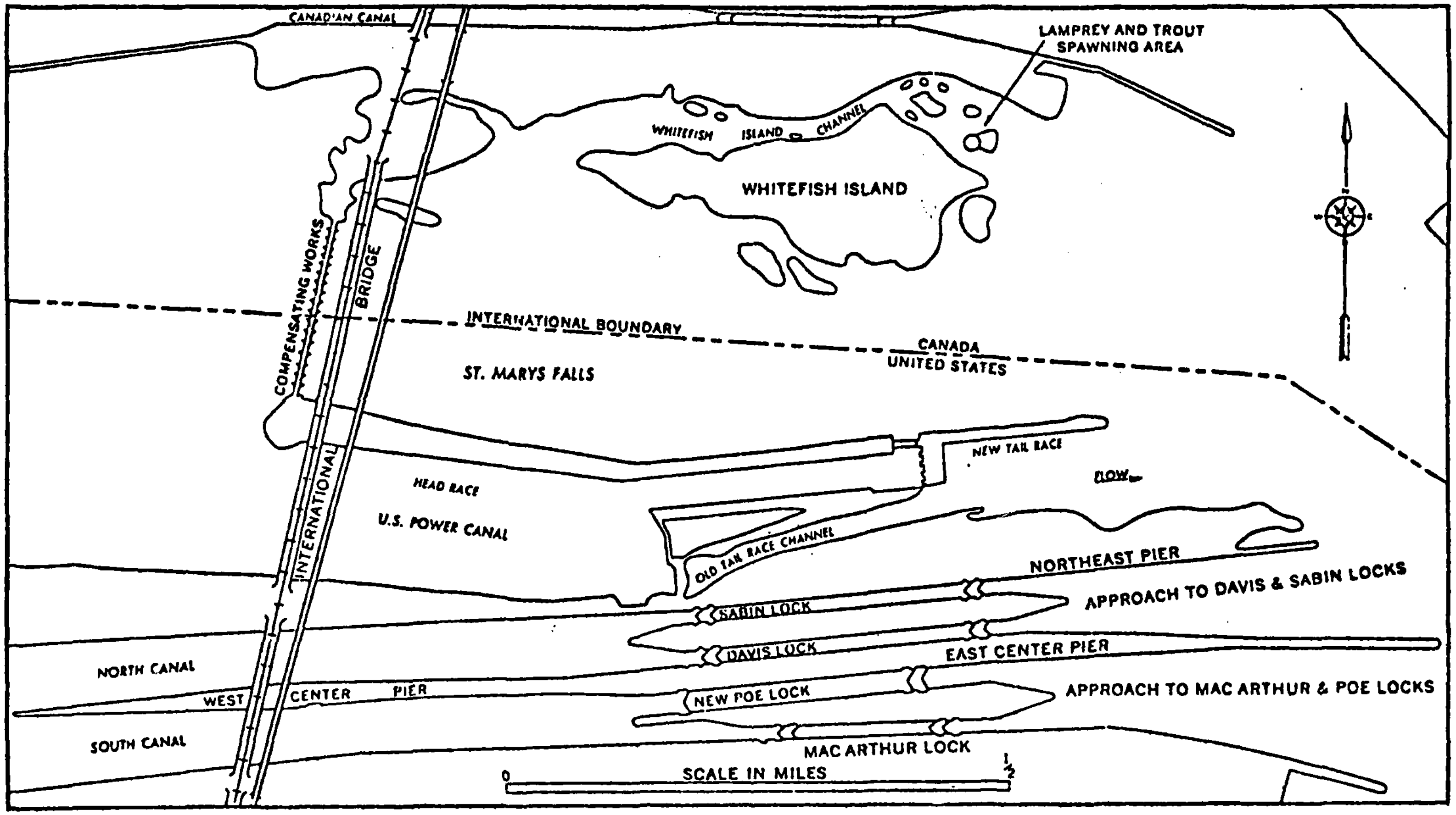


FIGURE 6.6 SOO LOCK SYSTEM

TABLE 6.4 SOO LOCKS DIMENSIONS (6, 3)

PRINCIPAL FEATURES	MacARTHUR	SABIN	DAVIS	POE	CANADIAN
Lock width, feet	80	80	80	110	59
Maximum ship beam, feet	75	75	75	105	-
Length between mitre sills, feet	800	1350	1350	1200	900
Maximum ship length, feet	730*	826**	826	1100***	-
Depth on upper mitre sill, feet	31	24.3	24.3	32	16.8
Depth on lower mitre sill, feet	31	23.1	23.1	32	16.8
Lift, feet	22	22	22	22	22

NOTES:

* 767 foot ships permitted with special handling.

** Downbound ships are generally depth-limited in the Sabin-Davis Locks.

*** Normal ship length is 1,000 feet; 1,100 foot ships require specialized locking procedures.

operating periods. The Sabin and Davis Locks can be shut down alternately because they have the same capacity; however, there are some problems in closing the MacArthur and Poe Locks since many of the downbound ships can only use these locks.

Routine maintenance is often required for the lock walls. Some cement deterioration occurs and repairs are made when the locks are closed. Modern ships using bow and stern thrusters direct high velocity water against the walls which has accelerated deterioration. Steel armor plates have been installed on some of the lock walls to prevent undercutting by the wash of the thrusters. The MacArthur Lock has plating on both sides, but the Poe Lock has plating on only one side.

Lock walls are also damaged by ice during late season and year-round operations. Thick accumulations of ice must be removed from the locks walls to permit operation of large ships that just meet lock size restrictions. This ice is generally removed from the lock walls by a tug with a large cutting blade installed on its bow. Although this method of ice removal has been successful, it has increased the deterioration of the lock walls. Air bubblers along the entire length of the Poe Lock walls are being used to help prevent ice accumulation.

The operation of large ships during ice conditions also places stress on the lock walls. The 105 foot beam ships have only a 2-1/2 foot clearance with lock walls on each side. When these ships are locked in the winter, there is very little space for the ice to be pushed away, which results in additional wear and damage to the lock walls. Lockage problems associated with 105 foot beam ships increase in heavy ice conditions.

Lock walls are protected by wooden fenders. These fenders are adequate but wear out quickly. Rubber fenders have been tried as an alternative but are considered to be too expensive for this application.

The Poe Lock has hydraulically operated gates that often leak causing a small oil spill problem. Mechanically operated gates would be more satisfactory because they are more durable in ice operations and do not have the problem of oil leakage.

Many modern ships have variable pitch propellers. These propellers run at a constant speed with a flat blade angle even when the ship has no way on. As a result, they create a wash astern that makes it more difficult to close the lock gates. In addition, these propellers could conceivably stick in an ahead or astern pitch position keeping the way on the

ship after it should be secured, which could result in the ship colliding with and damaging the lock gates.

Many of the large ships have winches that are inadequate for the size of the ship. Since the locking ships are stopped by the winches, this condition could also result in damage to the gates or lock walls.

Bow thrusters also tend to damage piers that are made of circular steel cells. This condition is currently being corrected by filling the space between the cells.

During winter ice conditions, ships must use high power settings to enter locks against the force of the ice. These high power operations tend to turn up ledge rock on the bottom of the channel, particularly at the approaches to the locks. Rock that has been dislodged by high power operations could accumulate and result in a reduced channel depth.

Many of the current maintenance problems are caused by operating in ice. If the navigation season is extended, higher maintenance costs can be expected. Year-round navigation will require a scheduled maintenance shut down, possibly during the summer navigation season. Scheduling a maintenance shut down is not entirely adverse, however, because in warm weather the maintenance procedures could be performed more easily, more rapidly, and less expensively. The locks do have some slack periods, even in the summer. If shippers are informed of scheduled maintenance periods well in advance, only a minimal dislocation in the flow of commerce is likely to occur.

Full season operations can be expected to result in some additional maintenance problems; however, this is not to suggest that operational or maintenance personnel are opposed to full season operations. On the contrary, full season operations are recognized as an important alternative to increasing the system capacity. Full season operations will require some modification to locking systems and operating procedures; however, once these adjustments have been made, full season operations can be expected to become routine.

6.3.3 Engineering and Economic Life

Good maintenance procedures can extend the engineering life of the locks for as long as the locks are required (6). Lock walls are repaired, lock gates are repaired or replaced, and lock operating machinery is either repaired or replaced. Given good maintenance, the locks can be used as long as they are needed.

The economic life of the system is a function of the type of ships that want to use the locks. Locks become obsolete because of ship size. There are currently three sizes of locks at the Soo. As ships become predominately larger, the shallow draft locks, the Davis and Sabin, will reach the end of their economic life. Since the MacArthur Lock handles deeper draft ships, it serves a large population of relatively new ships and will reach the end of its economic life much later. If new larger locks are not built, its life will tend to be extended because the ships that can be accommodated by the MacArthur Lock will continue to be used.

The question of the economic life of locks can also be viewed inversely. If new larger locks are built, new ships will also be built to the limit of the capacity of these locks, which will accelerate the end of the economic life of the smaller locks. Both the engineering and economic life of a lock is therefore related to other factors, such as the desired capacity of the lock system or the limit of capacity that can be built into the entire navigation system within a reasonable cost or level of engineering difficulty.

6.3.4 Planned Locks Improvements

Increased capacity for air bubblers is planned (6). These bubblers will keep ice from forming along the lock walls and therefore decrease the damage to the lock walls caused by the various procedures that are used to remove ice.

There is also a plan to install ice flushing valves. These gate valves would be installed to direct high velocity water across the surface of the water in the lock to flush ice out of the locking area.

6.3.5 Long Term Locks Capacity Limitations

In recent years the total number of ships using the locks has been decreasing, but the size of the ships has been increasing (6). With the number of large ships increasing, more ships can only use the Poe Lock. If the Poe Lock is closed by an accident or must be shut down for maintenance, the largest ships would be restricted to operating on specific trade routes above or below this lock. This could result in a severe economic hardship to the steel industry and some other industries as well. The Poe Lock is reported to be running at close to 60% of capacity now. A forced closing of this lock could result in a significant dislocation of normal commerce. In the view of operations personnel at the Soo Locks, this condition points to the

need for a second Poe sized lock. Figure 6.7 shows the 1981 population of U.S. and Canadian bulk freighters and self unloaders. Arrows show the classes of vessels that can use each set of locks (14).

Navigation season extension represents a major alternative for increasing the capacity of existing lock systems. Lock capacity in extended season operations is often limited by ice conditions (15). Ice affects lock operations in a number of ways.

When lock gates are opened, ice may drift in or locking vessels may push the ice in. Having ice in the locking chamber slows the locking process and often causes higher than normal loads on the lock walls and gates. Sometimes the ice must be locked out separately ahead of the vessel, which increases lockage time. Installation of special equipment for full season operations, such as ice flushing valves, will tend to minimize these problems.

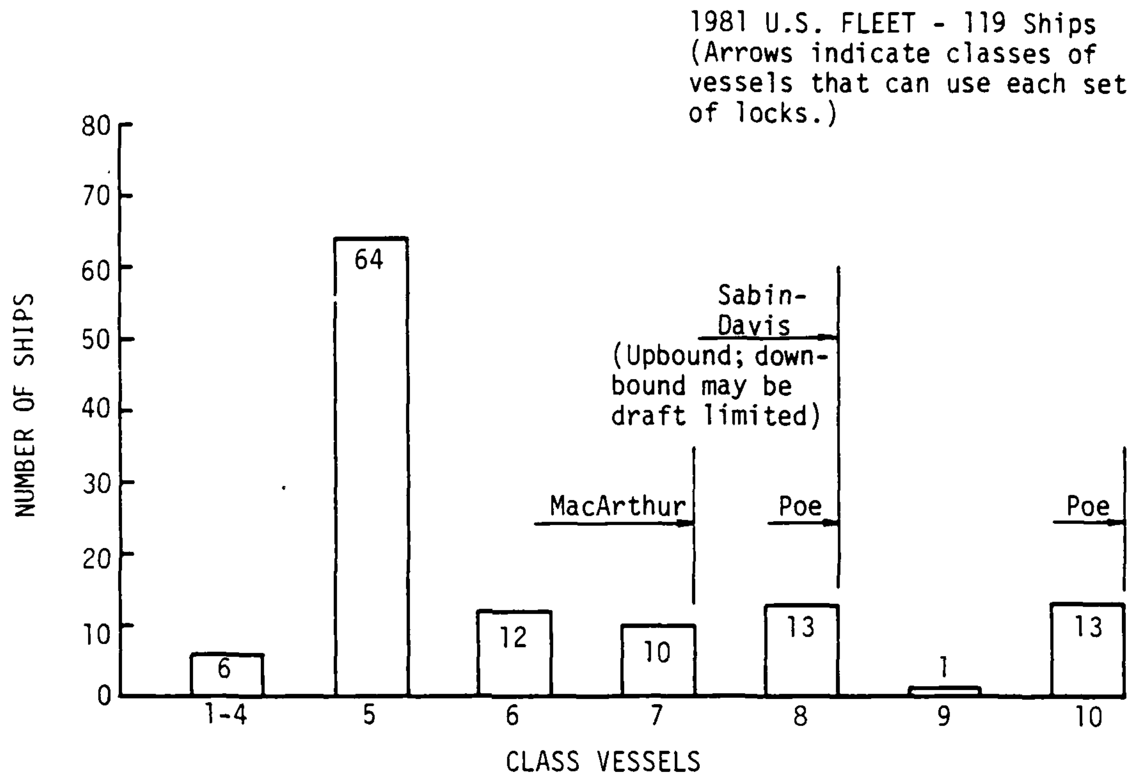
During cold weather ice accumulates on the lock walls every time a lockage is made. In some cases this ice forms a shelf up to three feet wide. In addition, vessels entering the lock chamber often have ice on their sides. This ice adheres to the lock walls increasing the accumulation. This accumulation of ice must be removed from time to time to permit continued locking of wide beam vessels.

Cold weather operations cause other malfunctions that eventually result in locking delays. Typical problems include valve freezing and malfunction of the mechanical or hydraulic equipment; however, once lock system components have been modified for cold weather, they could be expected to function normally.

6.3.6 St. Marys River Channel Restrictions

The use of the Soo Locks system is also limited by the channel restrictions and hazards to navigation that occur in the St. Marys River. Locks may sometimes be closed down because of fog or other problems in the approach channel. This section reviews some of the conditions in the channel that may affect lock capacity.

6.3.6.1 Structures - Two bridges cross the St. Marys River near the Soo Locks, and three submarine cables cross elsewhere along the river. The International Railway Bridge has a



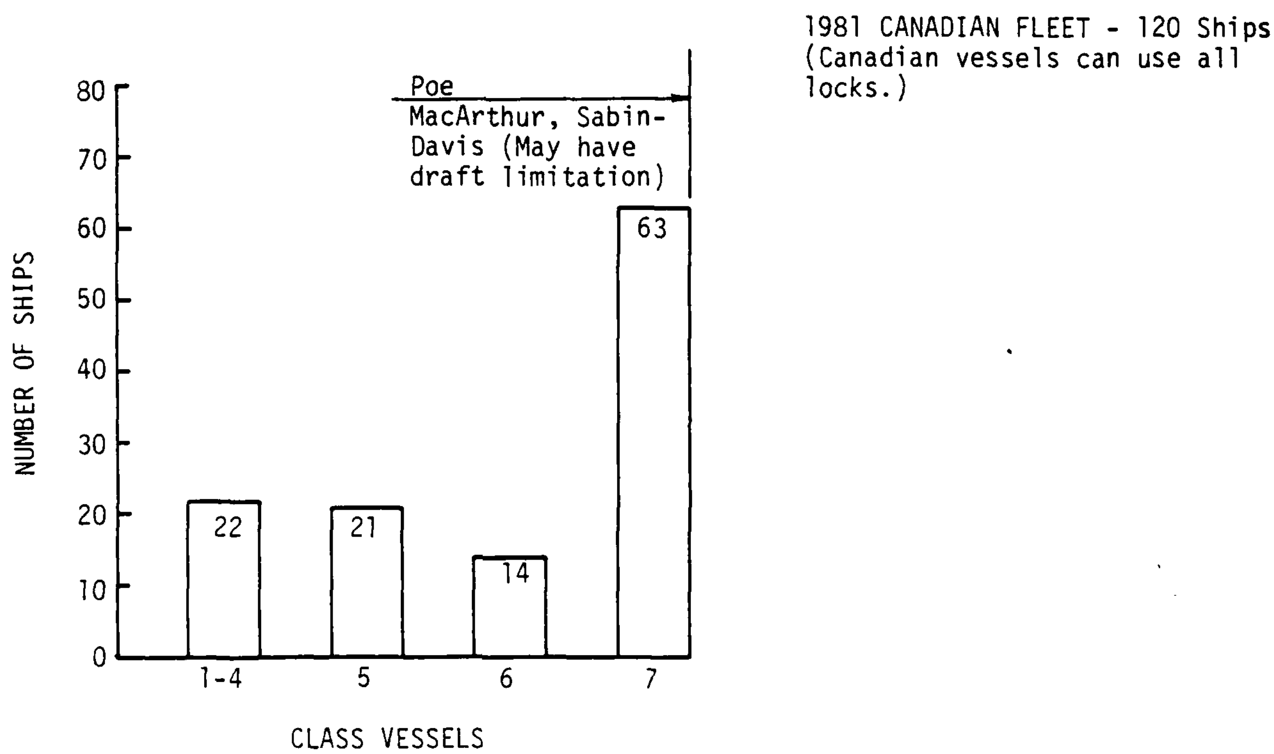


FIGURE 6.7 U.S. AND CANADIAN GREAT LAKES FLEET - BULK FREIGHTERS AND SELF-UNLOADERS (14)

lift span with a vertical clearance of 123 feet in the raised position. The other bridge is a double-leaf bascule that provides a clear opening when the spans are raised (4).

6.3.6.2 Navigation Hazards and Speed Limits - Sharp turns in a channel are sometimes hazards to navigation. At three locations in the St. Marys River, the channel width and degree of turn are such that vessels larger than the present 1000 foot length, 105 foot beam "lakers" are not likely to be able to navigate safely. These areas, Sailors Encampment, Little Rapids Cut, and Rock Cut, are shown in Figure 6.8 along with the speed limits along the St. Marys River. All speed limits are for speed over the ground rather than speed through the water; therefore, masters must determine their speed by time-distance checks rather than by revolutions per minute of the propeller. The currents adjacent to Neebish Island and in Little Rapids Cut vary between 1-1/2 and 2 miles per hour, with an expected low of about 1 mph and a high of about 3 to 3-1/2 mph (4).

All of the channels that are not split between upbound and downbound traffic are at least 700 feet wide permitting two way traffic. The St. Marys River has a minimum project depth of 27 feet. Figure 6.9 shows a cross-section of the project depths for the entire channel.

Ice also presents a hazard to navigation in the St. Marys River that is variable from year to year. As an example of these hazards, during the recent winter of 1980-1981, a Coast Guard cutter went to the assistance of a ship stuck in 12 to 18 inches of ice at Moon Island in the downbound channel on 17 December. On the same day, the Coast Guard prohibited ships from using the West Neebish channel after midnight and limited ships to one-way traffic on the Middle Neebish Channel. Another ship became stuck in the lower St. Marys River on 18 December and a cutter was sent to free her.

A number of specific icing problems occur seasonally that affect navigation in the St. Marys River. One of these problems involves pack ice (15). Pack ice consists of broken pieces of ice that have been consolidated and jammed together by winds and currents. As each winter storm drives more ice into relatively narrow openings, accumulations of pack ice increase in size until they extend as much as 30 feet below the water surface and reach a height of 15 feet or more. Low winter temperatures solidify the upper portions of this mass, which may present an obstruction to navigation during extended season operation. Breakup of the pack ice in the spring may also cause severe ice conditions in channels such as the St. Marys River.

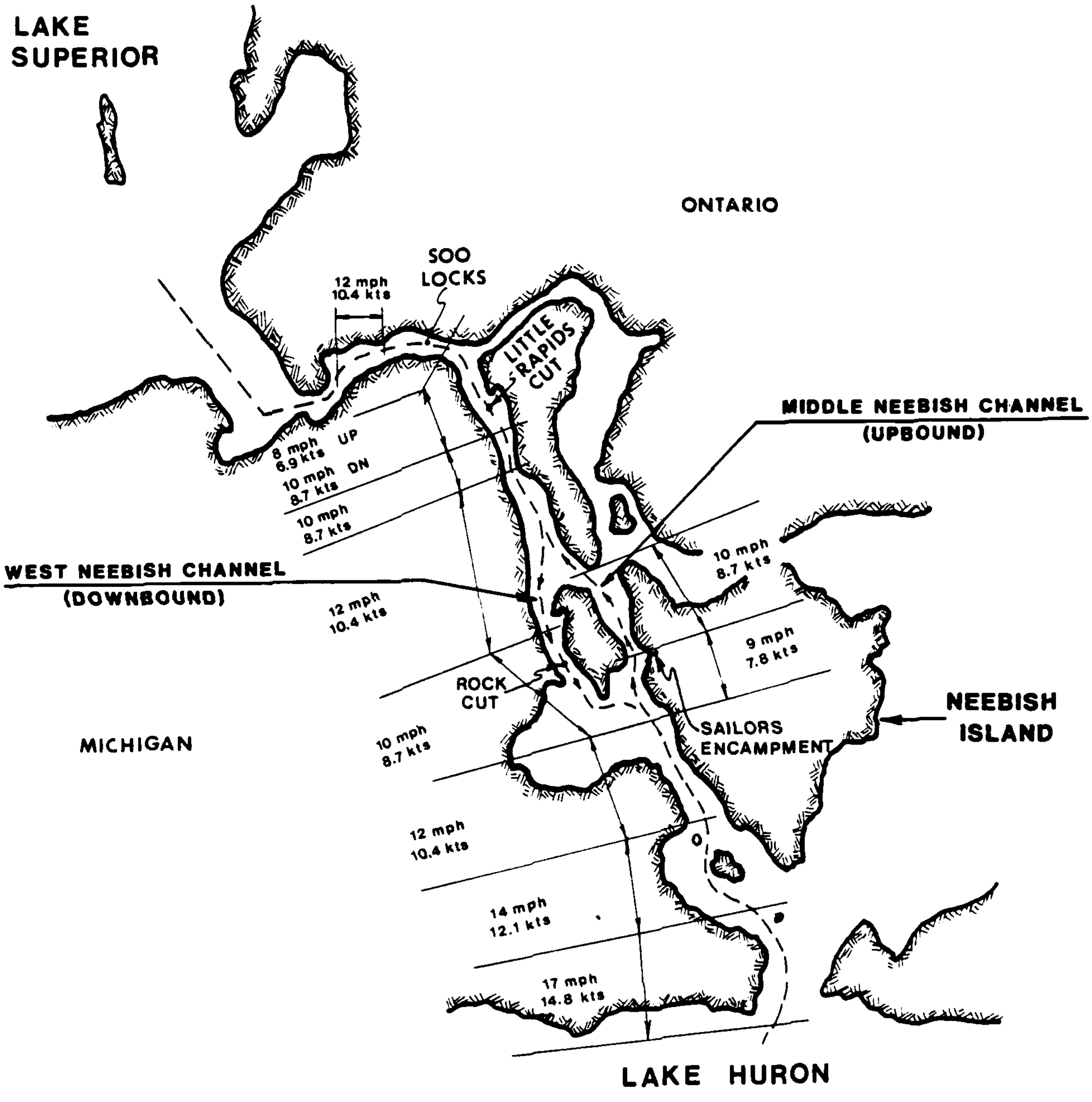
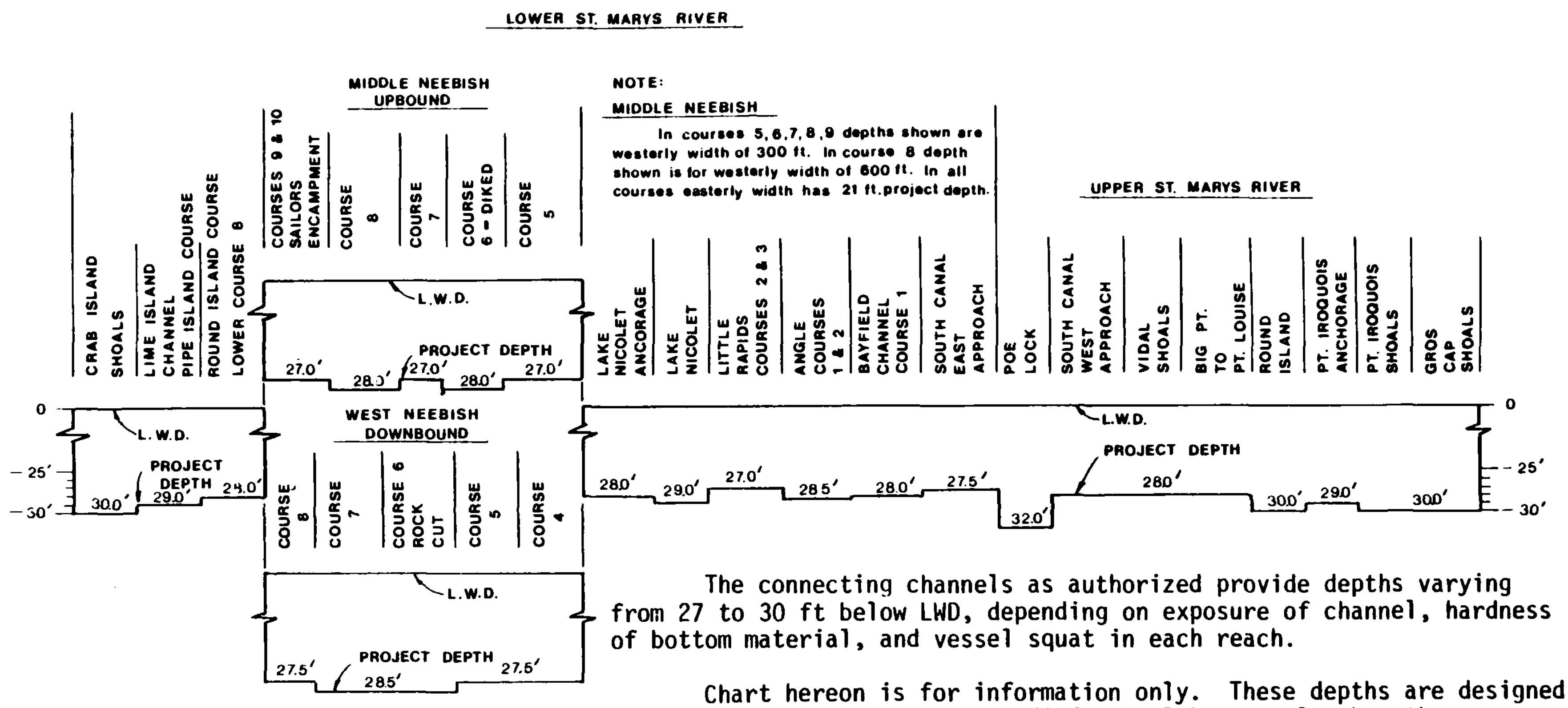


FIGURE 6.8 ST. MARYS RIVER CHANNEL - PRINCIPAL TURNS AND SPEED LIMITS [4, 16]



The connecting channels as authorized provide depths varying from 27 to 30 ft below LWD, depending on exposure of channel, hardness of bottom material, and vessel squat in each reach.

Chart hereon is for information only. These depths are designed to permit maximum draft of 25-1/2 ft for lake vessels when the water level is at LWD. However, the individual vessel Master should give further consideration to the peculiar characteristics of his vessel and to his individual clearance and safety requirements in determining the safe draft to which to load his vessel.

FIGURE 6.9 PROJECT DEPTHS IN THE ST. MARYS RIVER (9)

Slush ice can sometimes offer more resistance to navigation than pack ice (15). In some situations, slush ice with a depth of 6 to 8 feet can stop the movement of a lake freighter. In spring, wind and current conditions can drive slush ice from Lake Superior into the St. Marys River so that accumulations extend from the surface to the bottom (6). In these cases the channel may be closed for a period of one to three days (15).

Heavy vessel traffic through a channel can maintain an open track because the ice is pushed aside as fast as it is formed. This broken ice, however, may accumulate along the edge of the track to a height of 8 to 10 feet. If this ice grows out into the channel or is shifted by winds or currents, it may effectively close the channel. In areas with a broad reach of deep water, the usual practice is to abandon the original channel and cut a new one a few hundred feet away. This is not, of course, possible in restricted areas.

Ice accumulating along the edge of a channel presents problems on turns. A vessel may be able to move along the restricted space in the ice but not be able to make a turn. These ice conditions do not prevent winter navigation but simply indicate that icebreaker support is required for full season operations.

In the winter most lighted floating aids to navigation are removed to prevent their loss in the moving ice fields. Only the major fixed navigation aids and unlighted ice buoys are likely to remain. When channels have been cut through the ice, the vessel master can follow the channel; however, the ice fields may shift, in which case following the channel could result in a grounding. An advanced, highly accurate electronic navigation system will be required for navigation in most channels during full year-round operation.

6.3.6.3 Seasonal Levels and Flow Problems - Lake Superior has been regulated since 1921 by means of a gated dam across the St. Marys River at Sault Ste. Marie, Michigan. The objective of this control is to compensate for the effect of diverting water around the St. Marys River rapids for power. Construction of the gated dam was required by the International Joint Commission as a condition to approval of the water diversion. By operation of the gates and changes in power diversions, flows specified by the regulation plan can be achieved. The plan of regulation was designed to meet criteria specified by the International Joint Commission (15).

The water level in Lake Superior is limited to 2 feet above low water datum (LWD) or 602 feet elevation while Lake Huron and Michigan may be as much as 4 to 5 feet above their LWD (17). Since ships can load to deeper drafts in these lower lakes, there may be some benefit to deepening the channels in Lake Superior for bulk commodities that move between specific harbor pairs on these lakes (i.e., Duluth-Chicago). The controlling depth for this area is presently 27 feet in the St. Marys River.

Water level fluctuations as much as 5 feet have been known to occur within 3 hours in the St. Marys River. Since much of the sailing route is dredged channel, these level changes can affect safe vessel draft in the short run. However, over the project evaluation period, these variations are not a significant restriction to the system.

6.4 Straits of Mackinac

6.4.1 Physical Characteristics

The Straits of Mackinac, shown in Figure 6.10, connects Lakes Michigan and Huron. In most places, the channel in this strait is more than a mile wide and has a depth of over 50 feet. Only two locations of the channel are more restricted than the remainder of the channel. The Round Island Passage between Round Island and Mackinac Island has a depth of 30 feet and a width of 1250 feet. The Poe Reef Shoal in the South Channel has a depth of 30 feet. These areas are shown on Figure 6.10.

6.4.2 Channel Restrictions

6.4.2.1 Hazards to Navigation - In the summer the Straits of Mackinac have no special hazards to navigation other than normal hazards such as high winds, seas, and fog. In the winter ice is the principal hazard to navigation. Solid fields of pack ice are driven by prevailing winds from the northwest onto newly formed ice forming funnel-shaped sections that obstruct the channel (15). The pack ice is a problem both during the winter and at breakup. Since the channel is wide at Mackinac, the problem of ice building up along the edge of the broken channel is generally avoided by moving the broken channel a few hundred feet away periodically.

6.4.2.2 Water Levels and Flow - There is no perceptable flow through the Straits and therefore the seasonal depth varies with the depth of Lakes Huron and Michigan. Since the Straits

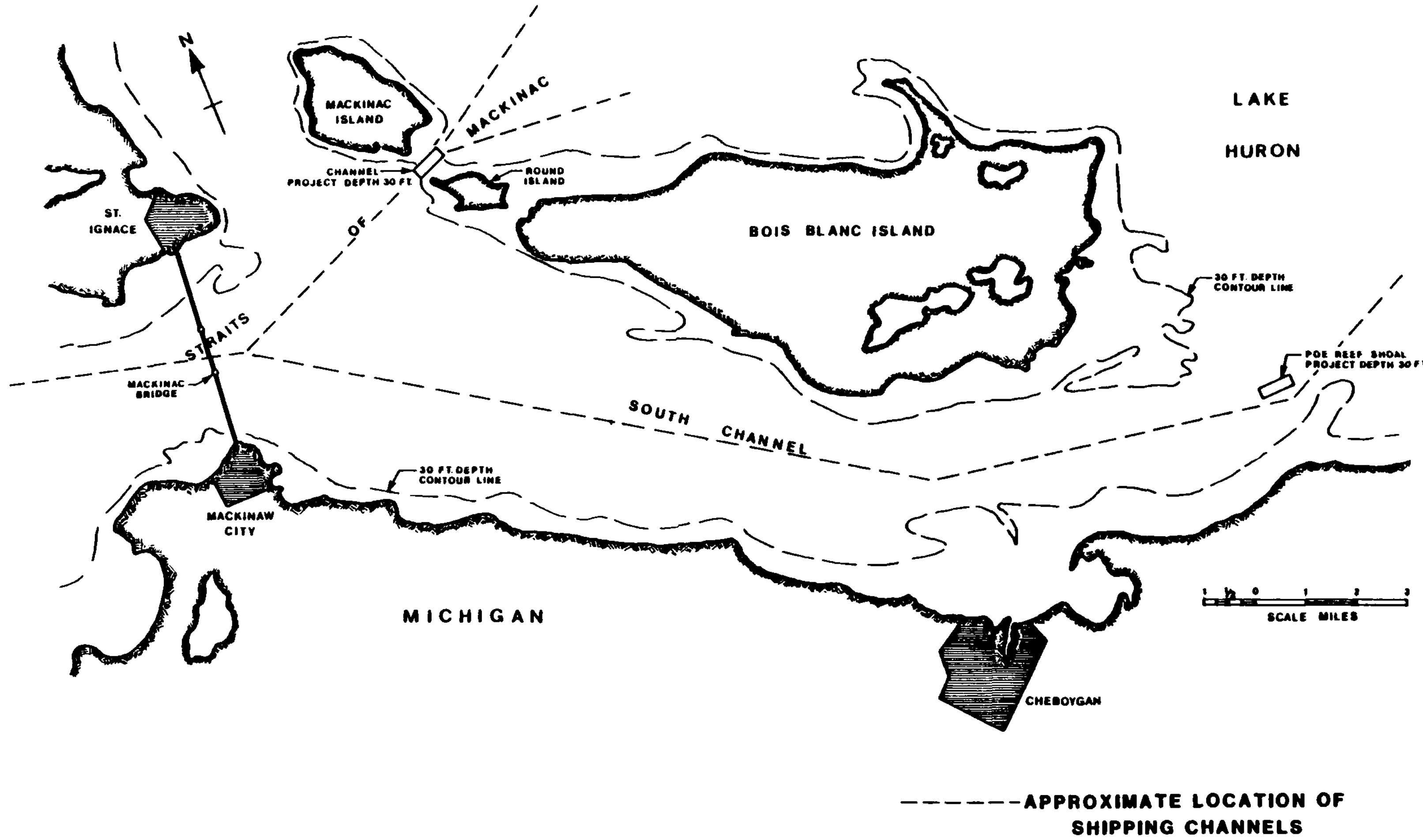


FIGURE 6.10 STRAITS OF MACKINAC

lie between these lakes, water level fluctuations caused by winds are not apparent. Changes in water level caused by changes in barometric pressure do occur in addition to the normal seasonal variations caused by variations in precipitation.

6.4.2.3 Structures - The Mackinac Bridge is the only above water structure across the Straits of Mackinac. The central suspension span over the main channel allows a clearance width of 3800 feet and a vertical clearance of 148 feet at the center, decreasing to 135 feet at the ends. There are three submerged cables and four submarine oil and natural gas pipelines west of the bridge. Two of the pipelines lie exposed below the 50 foot water depth contour while the other two are buried 15 feet below the 65 foot depth contour.

6.4.3 Planned Channel Improvements/Long Term Capacity Limitations

There are no known planned channel improvements or long term capacity limitations for the Straits of Mackinac. Round Island Passage and Poe Reef Shoal are not considered to constitute a capacity limitation.

6.5 St. Clair - Detroit River System

6.5.1 Physical Characteristics

The St. Clair River is the upper portion of the St. Clair-Detroit River System that extends from Lake Huron to Lake Erie. The river itself extends from Lake Huron to Lake St. Clair, as shown in Figure 6.11.

Lake St. Clair is a shallow basin between the St. Clair and Detroit Rivers. It contains no commercial harbors and one navigation channel dredged to a depth of 27.5 feet and a width of 800 feet.

The Detroit River is the lowest portion of the system, extending from Lake St. Clair to Lake Erie.

6.5.2 Channel Restrictions

6.5.2.1 Structures - There are two bridges crossing the St. Clair-Detroit River System, the Blue Water Bridge over the St. Clair River and the Ambassador Bridge over the Detroit River. Vertical clearances range from 133 feet to 156 feet while the clear width range is from 100 to 600 feet. Two tunnels cross under the channel with depths at mid-channel of 31 feet and

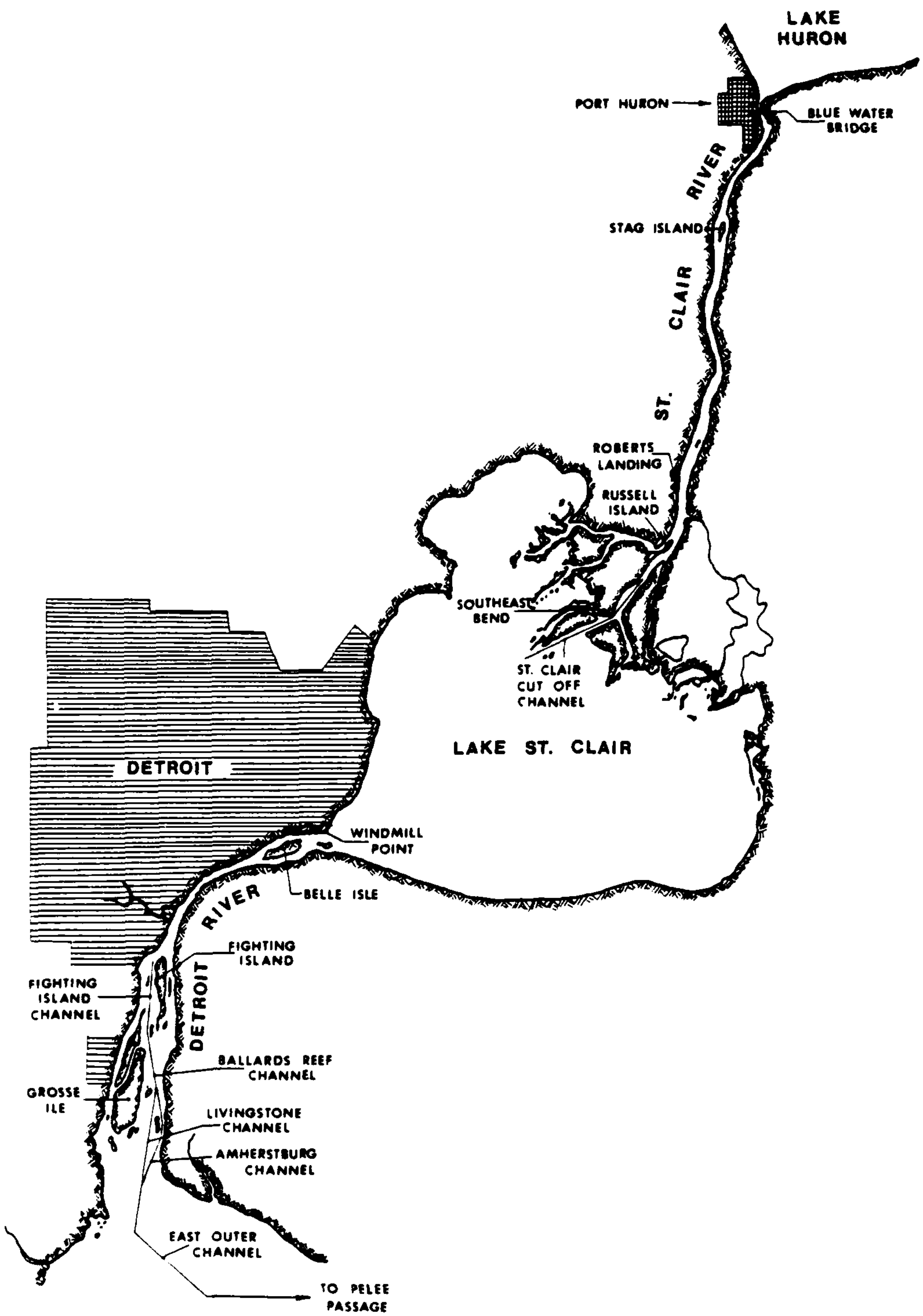


FIGURE 6.11 ST. CLAIR - DETROIT RIVER SYSTEM

40 feet. Other obstructions crossing the channel include three aerial cables, seven submerged cables, and eight submerged gas, water, and oil pipelines.

6.5.2.2 Navigational Hazards and Speed Limits - A turn in a channel that is not a navigation problem for a single vessel can be a problem for two vessels passing. There are three areas on the St. Clair-Detroit River that have this problem. Two are on the St. Clair River; Southeast Bend and Blue Water Bridge. Blue Water Bridge is restricted to one-way traffic although it has a clear span width of 600 feet. The other spot is in the lower Amherstburg Channel in the Detroit River. These areas and speed limits are shown in Figure 6.12.

Ice can be expected to be a winter hazard to navigation in the St. Clair-Detroit River System (15). The ice problem begins in the southern section of Lake Huron. This southern basin collects large amounts of drifting ice that can become concentrated at the entrance to the St. Clair River near Port Huron. Broken ice from Lake Huron also jams in the Lower St. Clair River near Harsen Island. The St. Clair River freezes over during severe weather conditions and icebreaker assistance would be required to implement a season extension program.

Lake St. Clair is shallow and therefore reacts quickly to wind conditions and temperature changes to form ice. Ice accumulates faster in the eastern half of the lake, which usually becomes ice-covered by the end of January. During the period of greatest ice cover there is thick, fast ice in the bays and protected areas, and heavy, consolidated floes of brash and cake in the midlake shipping channel (15). The head of the Detroit River is usually ice-free during the entire season except for minor jamming when drift ice becomes concentrated in the area. Breakup on Lake St. Clair occurs quickly. As the ice begins to melt, winds and currents move the drifting ice to the entrance of the Detroit River where strong currents move it downstream. The lake is usually ice-free in early March.

6.5.2.3 Planned Channel Improvements - There are currently no planned channel improvements for the St. Clair-Detroit River System. Requirements for improvements in this system will be considered as a part of the Connecting Channels study.

6.5.2.4 Water Levels - The St. Clair River has been known to fluctuate 2 feet in a short time because of high winds. The Detroit River can change as much as 6 feet in 8 hours. The change in Lake St. Clair is very moderate, taking several hours to change 1 foot. These fluctuations in water level may result

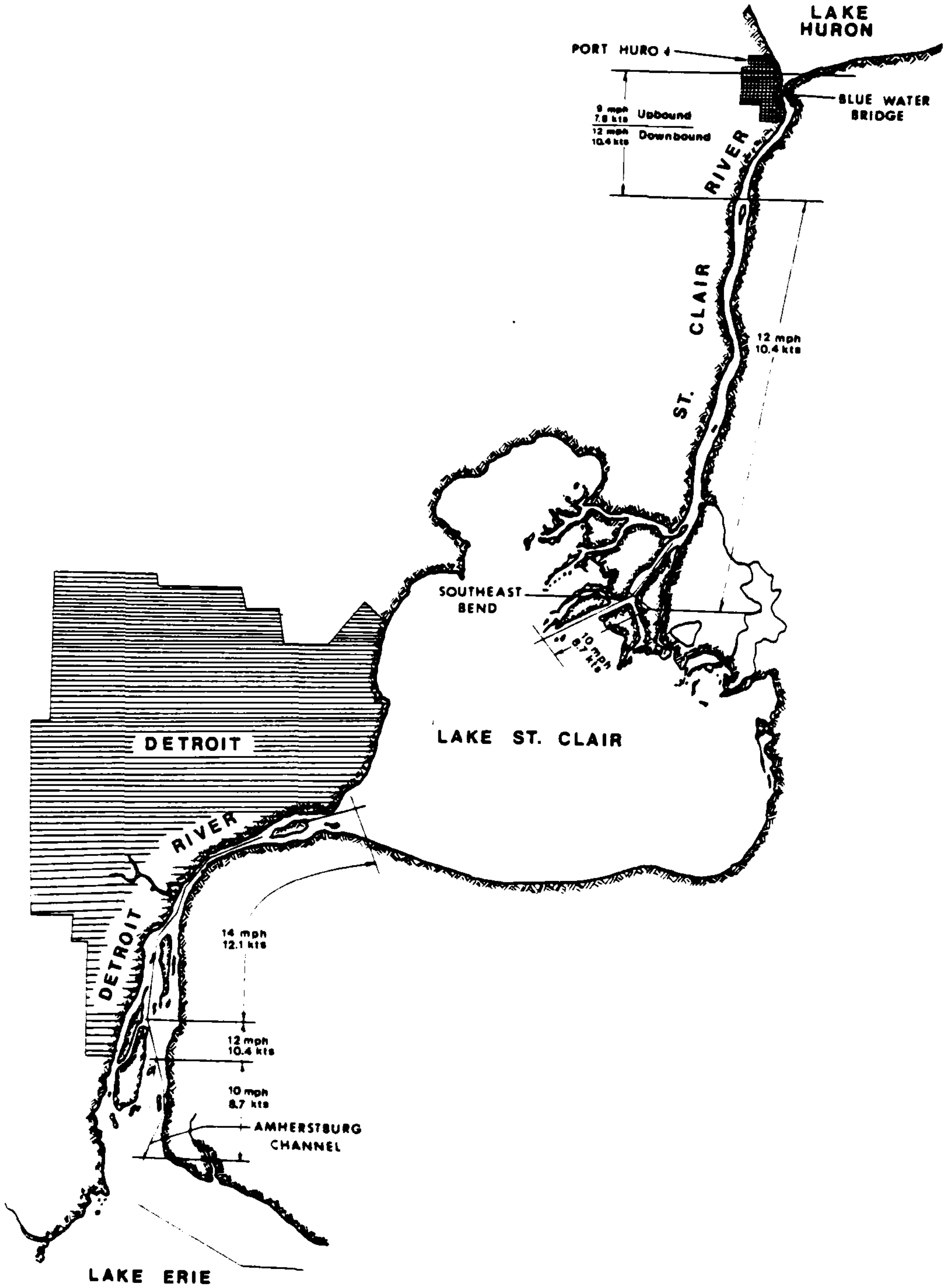


FIGURE 6.12 ST. CLAIR - DETROIT RIVER SYSTEM - PRINCIPAL AREAS AND SPEED LIMITS

in available water levels being less than the charted depths. Figure 6.13 shows the project depths in the St. Clair-Detroit River System. The controlling depth in this system is 27.1 feet.

6.5.2.5 Long Term Capacity Limitations - The long term capacity limitations in the St. Clair-Detroit River System will be affected by the hazards to navigation that occur in the system. Channel depth will affect increases in capacity. The controlling depth in the St. Clair River is 27.1 feet, and nearly all of the river has a depth of less than 27.4 feet. Further, all of the channel through Lake St. Clair requires dredging and currently has a project depth of 27.5 feet. Increases in system capacity through increasing allowable vessel draft are likely to require extensive dredging operations in this area.

Other hazards to navigation, such as the sharp turns in the channel and one-way traffic, are also likely to limit system capacity.

6.6 Lake Erie

6.6.1 Physical Characteristics

Lake Erie is the most southerly as well as the shallowest of the Great Lakes (4). Because of the extensive dredged areas in the western end, it must be considered along with other channel restrictions. Lake Erie is a waterway connecting Lake Ontario, via the Welland Canal, to Lake Huron.

The maximum depth of Lake Erie is 210 feet just southeast of Long Point, Ontario. The average depth over the entire lake is 62 feet (4). The deepest part of the lake is in the east and the shallowest section is among the islands in the west.

6.6.2 Channel Restrictions

There is a dredged channel from the mouth of the Detroit River in the western end of the lake all the way to Toledo, a distance of about 45 miles. The entire area west of Pelee Island is shallow, with depths ranging from 29 to 36 feet. Ships proceeding eastbound use shipping lanes through Pelee Passage, which has natural depths of 30 to 39 feet. East of Pelee Passage water depths are more generally in the 60 to 80 foot range with some depths in excess of 200 feet.

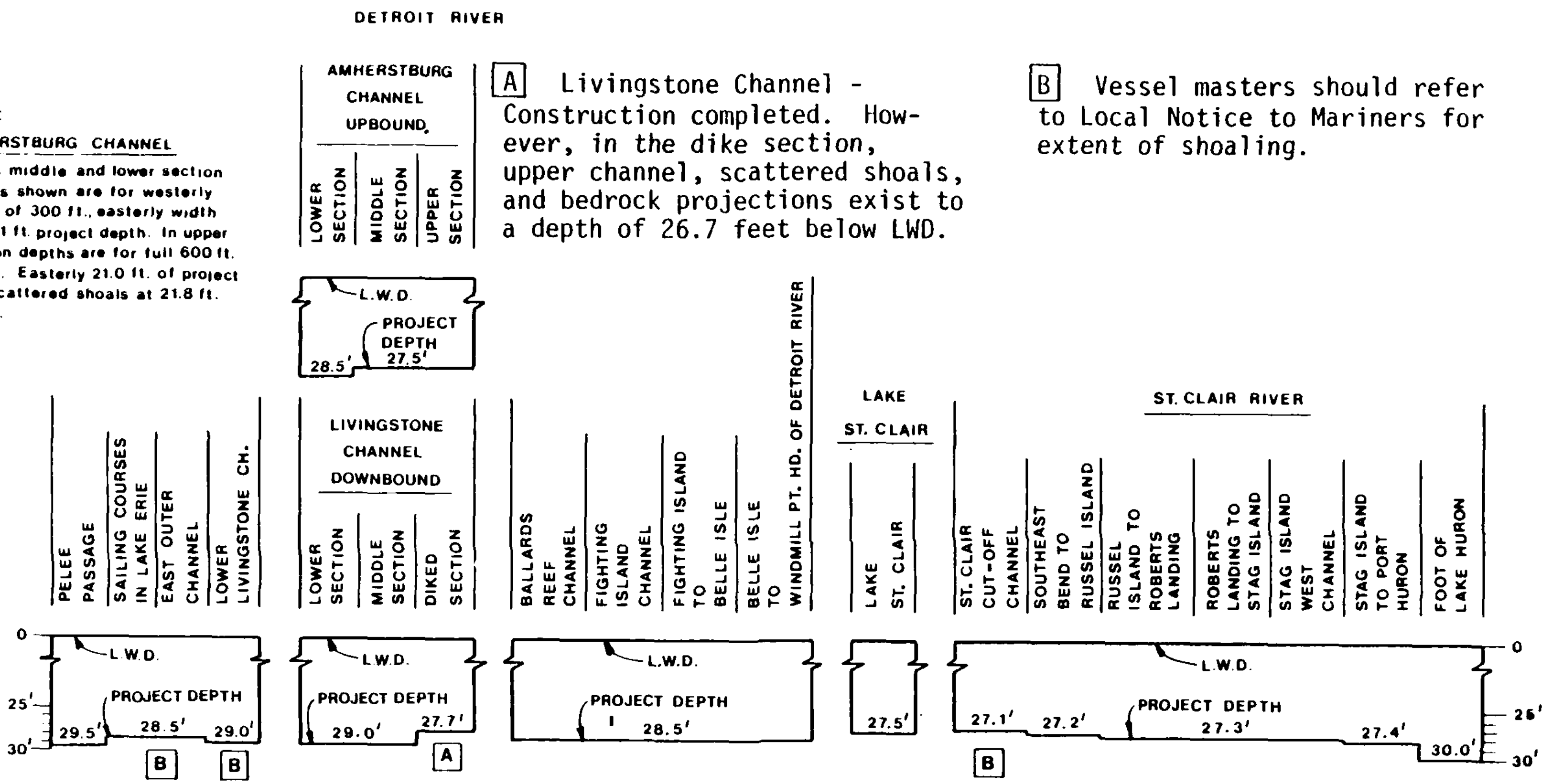
NOTE:

AMHERSTBURG CHANNEL

In middle and lower section depths shown are for westerly width of 300 ft., easterly width has 21 ft. project depth. In upper section depths are for full 600 ft. width. Easterly 21.0 ft. of project has scattered shoals at 21.8 ft. depth.

[A] Livingstone Channel - Construction completed. However, in the dike section, upper channel, scattered shoals, and bedrock projections exist to a depth of 26.7 feet below LWD.

[B] Vessel masters should refer to Local Notice to Mariners for extent of shoaling.



The connecting channels as authorized provide depths varying from 27 to 30 ft below LWD, depending on exposure of channel, hardness of bottom material, and vessel squat in each reach.

Chart hereon is for information only. These depths are designed to permit maximum draft of 25-1/2 ft for lake vessels when the water level is at LWD. However, the individual vessel Master should give further consideration to the peculiar characteristics of his vessel and to his individual clearance and safety requirements in determining the safe draft to which to load his vessel.

FIGURE 6.13 PROJECT DEPTHS IN THE ST. CLAIR - DETROIT RIVER SYSTEM (9)

6.6.3 Planned Channel Improvements/Long Term Capacity Limitations

There are currently no planned channel improvements. The channels in the western end of Lake Erie do not restrict the capacity of the system.

6.7 The Welland Canal and Locks

6.7.1 Physical Characteristics and Vessel Constraints

The Welland Canal, shown in Figure 6.14, is located approximately 20 miles west of the Niagara River and connects Lake Erie to Lake Ontario. The canal contains eight locks over a distance of 27 miles that provide a lift of 326 feet between Lake Ontario and Lake Erie. Of the eight locks, Locks 1 through 7 are lift locks, while Lock 8 is primarily a guard lock. Locks 1, 2, 3, and 3 are single locks that handle both upbound and downbound traffic. Locks 4, 5, and 6, called "flights" because they resemble stairs, lift ships a total of 136 feet over the Niagara Escarpment. These locks are twinned permitting parallel traffic, but each set of three locks is essentially a single lock system because once a ship enters it must be locked all the way through before the next ship is serviced. Lock 7 is considered to be the most constraining lock in the system because of its longer locking time and because of its somewhat curving channel located only about 1800 feet away from the flights. Table 6.5 shows the lock dimensions and the maximum ship size.

The navigation season at the Welland Canal is variable depending on vessel traffic; however, the canal generally closes about 31 December and opens about 25 March.

6.7.2 Channel Restrictions

6.7.2.1 Structures - The canal is crossed by 12 bridges, 4 of which are railway bridges, and the remainder highway bridges. Two road tunnels cross under the canal, one at Thorold south of Lock 7, and one at the By-Pass Channel north of Mile 18. A road-rail tunnel also crosses under the By-Pass Channel south of Mile 20. The lift bridges and narrow channels are also considered to be bottlenecks to vessel traffic. Speed limits, not including lock approaches, are shown in Figure 6.14.

6.7.3 Hazards to Navigation

All of the normal hazards to navigation occur in the Canal; winds, restricted visibility, and navigation in restricted waters.

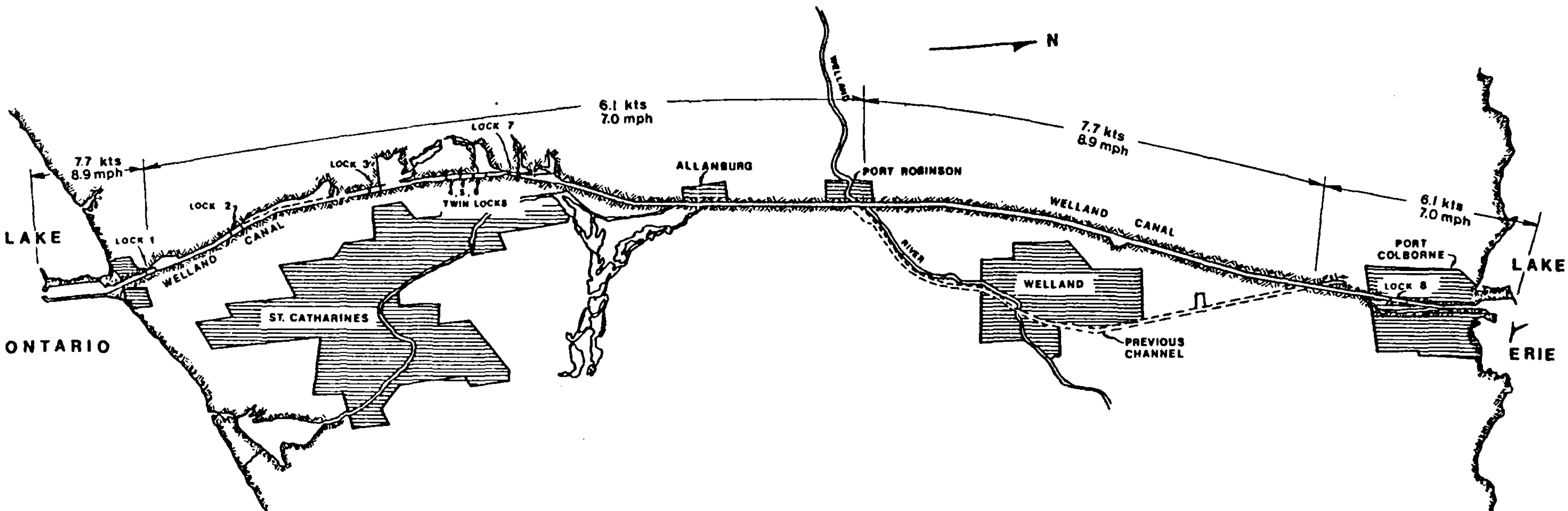


FIGURE 6.14 THE WELLAND CANAL AND LOCKS

TABLE 6.5 WELLAND CANAL LOCKS DIMENSIONS (18)

LOCK	LENGTH (ft)	WIDTH (ft)	DEPTH OVER SILLS (ft)	LIFT (ft)
All locks	766[1]	80	30	46.5[3]
Maximum Ship Size	730	76	26 (draft)	
Lock 1	865[2]			
Lock 2-7	859[2]			
Guard Lock 8	1380[2]			

NOTES:

1. Breast wall to gate fender.
2. Center to center of inner gate pintles.
3. Lift for Locks 1 to 7; variable lift for Lock 8, normally less than 3 feet.

Low visibility conditions are a particular hazard because of the danger of hitting a bascule bridge or a lift bridge. Collisions with bridges have occurred, and these accidents can cause the canal to be closed for a period of days.

Navigation is also restricted in some areas because of one-way traffic. A 4.5 mile section of the reach between Locks 7 and 8 is restricted to one-way navigation. A phased widening program will reduce the length of the restricted channel to 3.0 miles for the 1982 season. The effect of the one-way restriction should be minimal after widening is completed.

Hazards to navigation also occur because of ice. The problems of ice in the locks are about the same as those previously described for the locks at the Soo. Ice presents problems in locking vessels--sometimes large floes of ice must be locked through separately, locking times are increased because of the ice that forms on the lock walls, and lock walls and gates must periodically be cleared of ice, which also delays the locking process. In spite of these problems, responsible operations personnel at the canal believe that once locking systems and operating procedures have been modified for ice conditions, full season operations can be expected to become routine (7).

In the approaches to the canal, there is a ship traffic problem at Port Colborne caused by ships moving to and from fueling piers. At the other end of the canal, there is a problem of silting at the approach to the canal in Lake Erie.

6.7.3.1 Seasonal Levels and Flow Problems - The flow through the Welland Canal is controlled and therefore there are no special flow problems. The canal is designed for a depth of [illegible] feet, but because Lakes Erie and Ontario are presently higher than normal, 28.5 to 29 feet of water are currently kept in the [illegible]. This high water condition is not seasonal but rather varies over decades. Regardless of these variations, [illegible] ship draft in the canal is kept at 26 feet.

[illegible] Maintenance Problems

There are currently no major maintenance problems. Some [illegible] are very old and require refacing. There is pre[illegible] concrete rehabilitation program underway. All of the [illegible] be upgraded over a number of years (19).

6.7.5 Engineering and Economic Life

Current maintenance procedures can extend the engineering life of the locks for as long as they are needed. Lock walls are repaired, lock gates are repaired or replaced, and lock operating machinery is either repaired or replaced. Given good maintenance, the locks can be used as long as they are required (19).

The economic life of the locks will only terminate when there is no more demand for the canal and locks system. Since the demand has continued to grow with no signs of slackening, the economic life of the system will continue indefinitely. The economic life of the system can only be ended by ship size. If ships become too large to be locked in the system, then demand will decrease.

6.7.6 Planned Locks and Channel Improvements

The Canadian St. Lawrence Seaway Authority is currently considering a shunter system to increase lock capacity after completing a trial program. The shunter is a type of tug that is used to accelerate the movement of ships in and out of the locks. This technique shows the greatest potential for achieving a fairly large increase in system capacity short of major structural changes in the system (20). The concept has the disadvantage of requiring a large capital expenditure for the tugs, and a very large continuing expenditure for operating the tugs.

A series of other projects are also being considered to increase lock capacity at the Welland. These include:

- Widening the canal between Bridge 11 and Port Robinson (this project is already underway)
- Removing Bridge 5 between Locks 3 and 4
- Realigning ten lock approach walls
- Providing computer-assisted scheduling.

6.7.7 Long Term Locks and Channel Capacity Limitations

Over the last decade the annual tonnage throughput of the canal has increased appreciably as fewer, but much larger, ships have been going through the system. Additional increases in capacity can be achieved by increasing the load of the ships

that are using the canal. This can be accomplished by increasing the size of the ships using the canal and reducing the number of ships that go through in ballast. Currently about half of the ships are going through the canal in ballast (11). The capacity of the system could be increased by reducing the number of ships transiting in ballast; however, ballast transits cannot be controlled since they are a function of commodity demand. Ballast transits could be discouraged by charging tolls by the lockage instead of by the ton.

Of all of the sections of the St. Lawrence Seaway System, the Welland Canal and Locks are closest to full capacity at the present time. A recent Seaway Authority study estimates that with no changes to the present Welland Canal System, full capacity will be reached in 1988. Although this estimate is based on projected economic conditions, the general time frame is significant in that most large scale projects that would result in an increase in capacity would take about ten to fifteen years to plan and complete.

The list of relatively minor physical changes described in the previous section is expected to increase the capacity of the system from an average of 31 lockages per day to 35 lockages per day, an increase of about 13%. If the proposed shunter system is used in addition to these changes, the capacity is expected to increase further to about 42 lockages per day, an increase of about 36%. These changes would, of course, delay the point at which the capacity limit is reached, but the delay gained by these measures may be only on the order of about 15 years.

Other means of increasing capacity have also been considered. Capacity could be increased by allowing larger vessels to use the system. If the locks are modified to accept longer or wider ships, there is also the problem of the ship's draft. Longer ships with a draft of 26 feet have been found to be less than desirable on the ocean. On the other hand, increasing the authorized draft of the entire system beyond the current 26 foot limit could involve tremendous costs and engineering problems.

Major changes in the Welland Canal system have also been considered. Serious consideration has been given to such changes as twinning all of the locks in the Welland System, or even building an entirely new canal with a four lock system. The St. Lawrence Seaway Authority is currently considering all possible measures for increasing the system capacity, including the alternative of building a new canal (19). Land that could be used for a new canal was purchased in 1968.

6.8 St. Lawrence River and Locks

6.8.1 Physical Characteristics and Vessel Constraints

The St. Lawrence River connects Lake Ontario to the Gulf of St. Lawrence. The St. Lawrence River Locks, shown in Figure 6.15, extend approximately 190 miles from St. Lambert Lock at Montreal to Kingston, Ontario, on Lake Ontario. The system currently has an 8 month navigation season starting in mid-April and ending in mid-December.

The St. Lawrence River Locks system was created by excavation of channels to a depth of 27 feet and the construction of seven single locks to by-pass certain rapid sections of the river (11). Of the seven locks, two are operated by the United States; the Snell and Eisenhower Locks located near Massena, New York. Five locks are operated by Canada; the St. Lambert and Cote Ste. Catherine Locks located near Montreal, the Upper and Lower Beauharnois Locks located in the Beauharnois Power Canal, and the Iroquois Lock located at Iroquois, Ontario.

The major constraint to traffic is generally considered to be the Beauharnois Locks. These locks are relatively close together and provide no waiting area for vessels between the locks. In addition, during the peak summer months, the Beauharnois Locks experience a strong seasonal demand for lockages by pleasure craft that are cruising in the vicinity of Montreal, Quebec.

All seven locks are similar in size and all are capable of locking a ship that has a length of 730 feet, a beam of 76 feet, with an authorized draft of 26 feet (11). Table 6.6 shows the detailed lock dimensions and ship capacity.

6.8.2 Locks Maintenance Problems

The Eisenhower Lock has had problems with concrete deterioration, however these problems are being corrected (22). An engineering survey is presently underway to examine a number of aspects of lock condition. This survey is looking at lock stability and determining the properties of the backfill as it is related to stability. The condition of the locking machinery is also being examined, as is the availability of spare parts to support the system since the machinery is now 23 years old. The general physical condition of the locks is good and will not be a factor in determining the future utility of the locks.

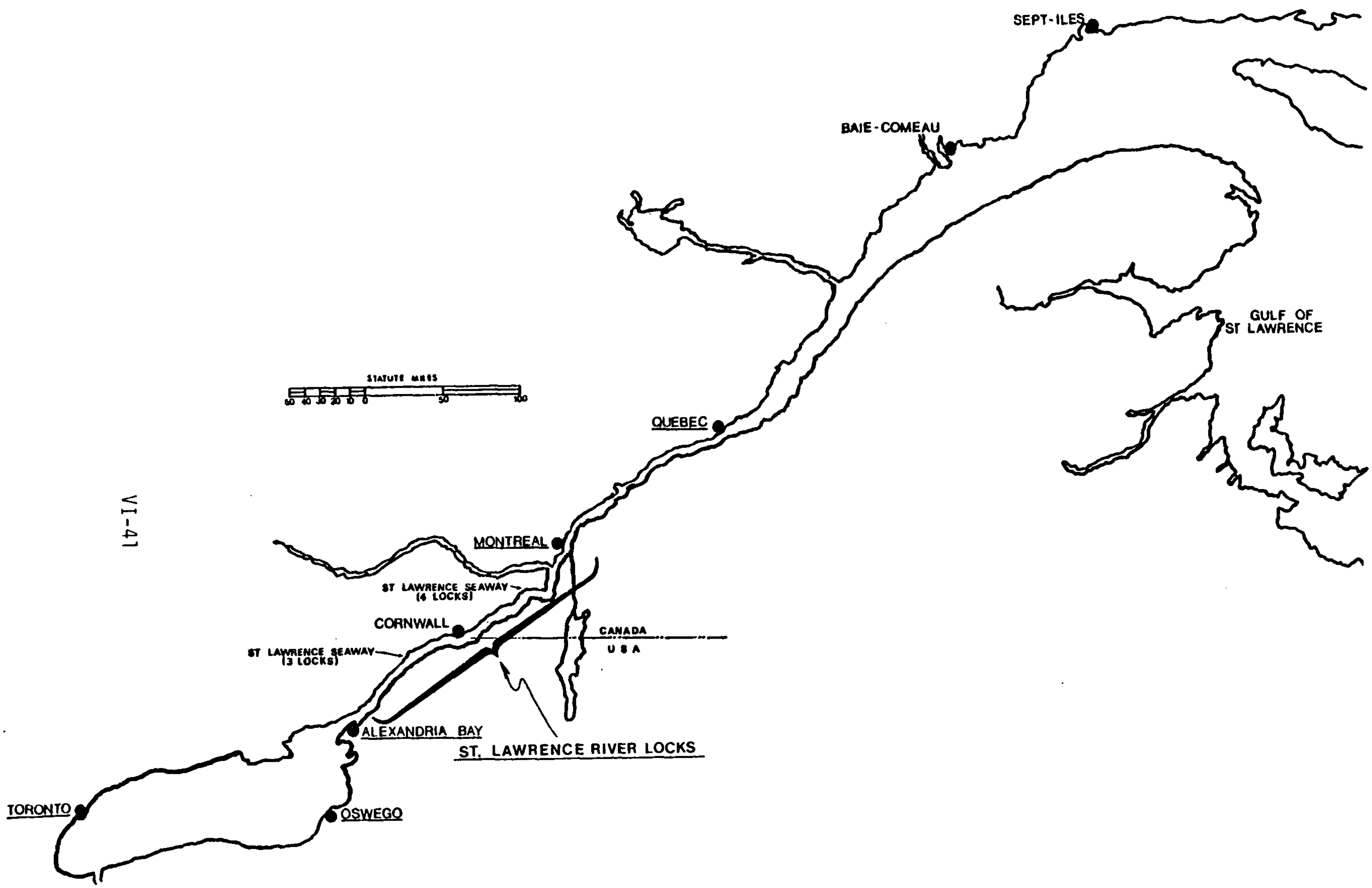


FIGURE 6.15 THE ST. LAWRENCE RIVER AND LOCKS

TABLE 6.6 ST. LAWRENCE RIVER LOCK DIMENSIONS (21)

Length, breast wall to gate fender	766 feet
Width	80 feet
Depth over sills	30 feet

Ships may not exceed 730 feet in overall length or 76 feet in maximum beam or 26 feet draft (11).

Locks	Range of Lift in Feet
St. Lambert	13 to 22 feet
Cote Ste. Catherine	28 to 37 feet
Lower Beauharnois	38 to 42 feet
Upper Beauharnois	36 to 40 feet
Snell	45 to 49 feet
Eisenhower	38 to 42 feet
Iroquois	0.5 to 6 feet

6.8.3 Engineering and Economic Life

With continuing maintenance, the engineering life of the locks is indefinite. The economic life of the locks is only limited by demand. As long as the locks serve the size of ships that are carrying the cargo, the economic life will continue.

6.8.4 Planned Locks Improvements

During this past year a surface flushing system was installed at the Eisenhower Lock (22). This system can flush ice out of the lock chamber in about 5 minutes. Using this system improves the late fall and early spring locking times. A similar system will be installed at the Snell Lock. Other anti-ice measures have also been installed at the locks, including heating for fender gate mechanisms, bubbler flushers, and an underwater air curtain at the upstream entrance of the locks that sets up a current that keeps the moving ice out of the locks.

6.8.5 Long Term Locks Capacity Limitations

The St. Lawrence River Locks are not near capacity and are not likely to reach capacity in the near term based on the projected traffic flow (22). One study shows that the St. Lawrence Locks may reach capacity by the year 2000 (21). The Welland Canal is currently the section of the system that controls capacity since many of the vessels passing through the St. Lawrence River Locks must also transit the Welland Canal. The St. Lawrence River Locks are not expected to approach capacity unless a major improvement occurs at the Welland Canal that allows future traffic growth, measured by vessel transits or commodity flows, to be accommodated at locks in the St. Lawrence River.

6.8.6 St. Lawrence River Channel Restrictions

6.8.6.1 Structures - There are 17 bridges across the St. Lawrence River. Minimum clearance height is 120 feet and minimum clearance width is 80 feet. Five of the bridges have the 80 foot clearance width while the rest have greater than 180 foot minimum clearance width.

Twelve aerial cables cross the river above St. Regis with clearance heights from 120 feet to 210 feet. Twenty-four submerged cables also cross the river.

6.8.6.2 Navigation Hazards and Speed Limits - Strong cross currents are sometimes a hazard to navigation in the St. Lawrence

Channel. At Pollys Gut, just west of Cornwall Island, the current sets through the Gut at a rate of between 3 and 6 knots (23). This current had been a problem for westbound ships moving into the Snell Lock; however, in 1976 a spur was built out into the stream to redirect the cross current. This improvement now permits ships to make a normal approach to the Snell Lock. Similar problems with current occur at Copeland Cut, Galop Island, and Ogden Island. High crosswinds may halt traffic under bridges in some locations and may require a one-way traffic restriction to be imposed in some channels.

Fog can be a hazard to navigation on the St. Lawrence River, particularly during the summer when southwest winds bring warm moist air (23). In spring and fall, reduced visibility is more likely to result from rain, particularly in the area of Montreal.

Extended season navigation in the St. Lawrence River would require the installation of a highly accurate electronic navigation system over the entire length of the channel since the normal navigation buoys must be removed in the winter. Although there are some systems available with the necessary level of accuracy, installing these systems along the entire length of the channel may be prohibitively expensive. Ships moving through the ice would also have the same kinds of problems that were previously described for the St. Marys River. Ships would have trouble moving in slush ice, channels would have to be cut by icebreakers, ice build-up along the edge of channels is likely to be a problem, and ships can be expected to have trouble making sharp turns in channels that are lined with high ridges of ice. In winter, the ice thickness in channel sections may average 2 to 3 feet, while lake and river ice may only reach a thickness of 1.5 to 2.5 feet (23). Extending the season to 10 months at the St. Lawrence River Locks will require some modifications to locking systems and operating procedures; however, once these adjustments have been made, extended season operations can be expected to become routine. Many of the lock improvements needed for extended season operations have already been made and others are planned.

In many sections of the St. Lawrence River, power companies have installed ice booms to stabilize the ice in order to maintain a steady river flow for power production. In early studies of navigation season extension, it appeared that ships penetrating the ice fields retained by these booms could dislodge the ice and create ice jams that would affect river flow (15). Since that time ice booms that correct these problems have been designed and tested in both the laboratory and in the field (24, 25).

(Field tests of booms did not include actual vessel movements.) These booms provide an opening for ship traffic in the channel but still maintain the stability of the ice fields. Icebreakers would be required to keep these channels open as the thickness of ice increased.

Speed limits have been established in the channel to reduce the hazards of navigation and to minimize shoreline erosion. These speed limits are shown in Figure 6.16.

6.8.6.3 Seasonal Levels and Flow Problems - Tidal variations from Quebec seaward are quite large, up to 8 feet; however, at Montreal and inland the variation is only about 6 inches (23). At the Upper Iroquois, seasonal water variations result in water levels of more than 3 feet above datum through the summer. Summer water levels are likely to be only 1 or 2 feet above datum at other locations. Lake Ontario has been regulated since 1958 by means of a control dam that spans the St. Lawrence River near Iroquois, Ontario and by a powerhouse and dam at Barnhart Island, New York, near Cornwall, Ontario. Control of Lake Ontario was authorized by the International Joint Commission as part of the St. Lawrence Seaway and Power Project to meet the criteria specified in the Orders of Approval of the International Joint Commission (15).

6.8.7 Planned Channel Improvements

There are currently no plans for channel improvements.

6.8.8 Long Term Channel Capacity Limitations

Currently the capacity of the system is limited by the size of the vessels that can use the system. Vessel size is determined by the channel depth and the size of the locks. The channel and locks and presently accommodate the same size vessels as can use the Welland Canal. If the Welland Canal increases in size, then the St. Lawrence portion of the Seaway would also have to increase to provide physical access to, or exit from, the Atlantic Ocean to the upper four Great Lakes.

6.9 Visibility Limitations

Low visibility in the form of fog, rain, and blowing snow causes many interruptions in navigation on the St. Lawrence River. Low visibility is also the cause the many vessel collisions and groundings. Records of low visibility conditions in specific areas of interest are not readily available; however, some general

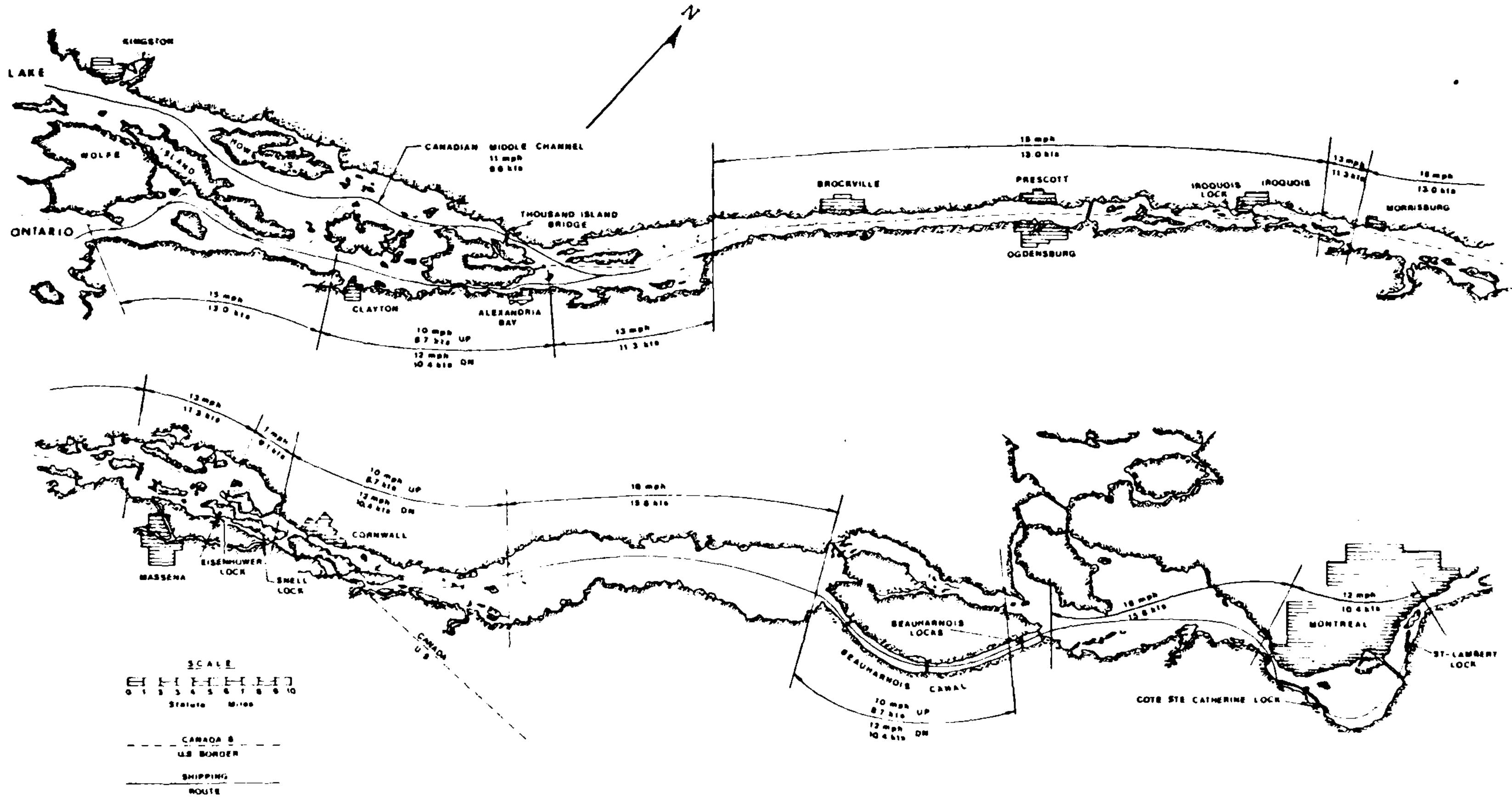


FIGURE 6.16 THE ST. LAWRENCE RIVER CHANNEL AND LOCKS

data on the number of days fog occurs is available. This information is therefore presented to identify the general areas where low visibility conditions are most likely to be a hazard.

The National Weather Service uses the following rules of thumb for visibility:

(1) Heavy fog restricts visibility to 1/4 mile or less,

(2) Light snow restricts visibility to 1/2 mile,

(3) Moderate snow restricts visibility to between 1/2 and 1/4 mile,

(4) Heavy snow restricts visibility to 1/4 mile or less.

There are no general criteria for visibility in rain; however, heavy rain may reduce visibility to 1/4 mile or less.

Fog days are defined in the United States and Canada as a day in which visibility is reduced below the minimum distance for any period of the day. Canada has a minimum distance criterion of 1/2 mile while the United States criterion is 1/4 mile. The number of annual fog days for various locations on the Great Lakes is shown in Figure 6.17. The criterion for this data is visibility less than 2-1/2 miles. Although this data does not show exactly how often navigation is halted because of low visibility, it does identify the general areas where fog is most likely to be a hazard to navigation. Figure 6.17 shows that low visibility is mostly likely to occur in the upper lakes area with the greatest frequency of low visibility days occurring at Duluth, Sault Ste. Marie, and Mackinac.

6.10 Harbors

The purpose of this section is to describe U.S. harbors in the GL/SLS System so that improvements to alleviate capacity constraints can be related to existing harbor facilities. To a certain extent, the capacity of the seaway is a function of the capacity of the harbors. In some cases, the limits to capacity in terms of tonnage carried may be as much a function of the efficiency of the ports as the capacity of the channels and locks. In some cases, ships are spending days queuing for port facilities so that they are effectively removed from the flow of traffic

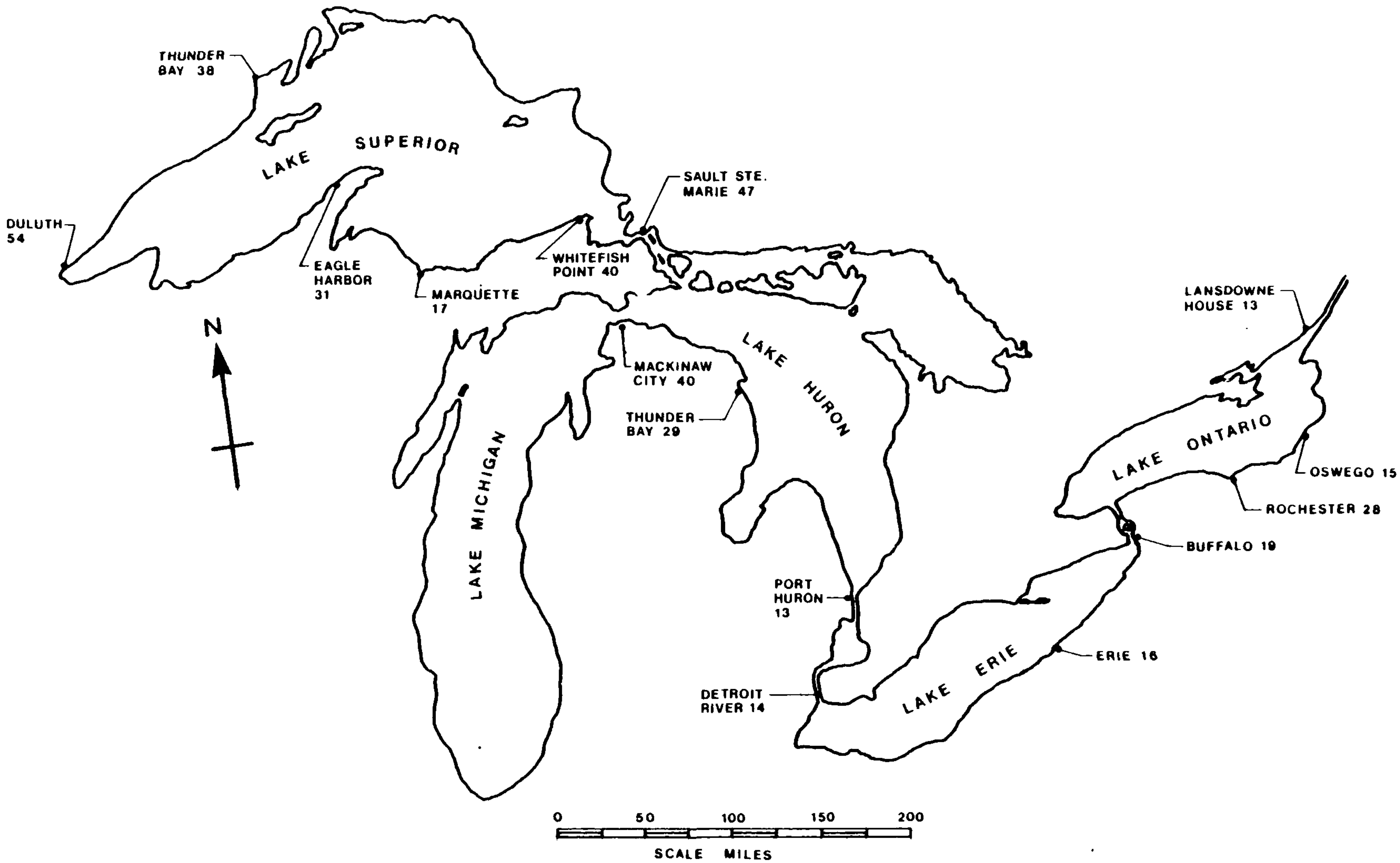


FIGURE 6.17 NUMBER OF ANNUAL FOG DAYS (26, 27)

through the system and thus reducing the capacity of the system. This task presents the details of port capability so that judgements can be made as to the effectiveness of the ports that are a part of the system.

Harbor descriptions have been provided in summary format for each lake and include a description of controlling depths, vessel restrictions, loading/unloading facilities, commercial navigation season, and authority for maintenance. Information on planned harbor development was obtained from the appropriate District Corps of Engineers Office.

6.10.1 Lake Superior Harbors

TWO HARBORS, MN

Controlling Depths

Authorized - 28 ft inner basin, 30 ft near entrance.
Actual - Authorized depths maintained except 26 to 28 ft within 100 ft of east project line.

Vessel Restrictions

Draft - Docks range from 18 to 28 ft.
Length - 1,000 ft, plans for 1,300 ft.

Loading/Unloading Facilities

No docks are publicly owned.
3 active ore docks, 1 liquid cargo dock.
1 inactive dock and merchandise wharf.

Commercial Navigation Season

Begins - Earliest 2 April, latest 15 May.
Ends - Earliest 20 November, latest 2 February.

Authority for Maintenance

Existing project authorized by the 1886, 1935, 1945, and 1960 Rivers and Harbors Acts. Pre-1950 authorized work is complete. Work remaining is to deepen 26 ft areas to 28 ft and remove rock from the easterly and northerly edges.

Vessel Length and Beam Limitations

No restrictions (16).

DULUTH-SUPERIOR, MN-WI

Controlling Depths

Authorized - 28 to 32 ft channel entrances and basin, 27 ft iron ore route channels, 20 to 23 ft inner channels.
Actual - Authorized depths maintained except for 20 ft shoaling in some channels.

Vessel Restrictions

Draft - Depth within 35 ft of piers at Superior entrance is limited by 16 ft riprap.

Loading/Unloading Facilities

113 docks or terminals, all privately owned except one.
Can handle iron ore, coal, limestone, petroleum, steel, scrap iron, cement, general cargo, and grain.

Commercial Navigation Season

Begins 3 April.
Ends 11 January.

Authority for Maintenance

Existing project authorized by 1896, 1902, 1907, 1908, 1916, 1919, 1927, 1930, 1952, 1960, and 1961 Rivers and Harbors Acts. Project is complete except for 21st Avenue West Channel portion which is inactive.

Planned Harbor Development

The Duluth-Superior Harbor, Minnesota and Wisconsin study of improvements is in the planning stage. The principal alternatives examined in the planning stage were deepening the existing channels from 23 ft to 27 ft or from 23 ft to 25 ft from mile 4.0 to mile 7.3.

Vessel Length and Beam Limitations

None (28).

PRESQUE ISLE HARBOR, MI

Controlling Depths

Authorized - 28 ft inner basin, 30 ft approach.
Actual - Authorized depths are maintained.

Loading/Unloading Facilities

1 ore dock
1 merchandise and petroleum wharf
Overhead coal conveyor for Upper Peninsula Generating Company.

Commercial Navigation Season

Begins - Earliest 21 March, latest 30 April.
Ends - Earliest 26 November, latest 24 January.

Authority for Maintenance

The existing project was authorized by the 1896, 1902, 1935, and 1960 Rivers and Harbors Acts. Project is complete.

Vessel Length and Beam Limitations

Vessel length 1,000 feet, beam 54 feet (14).

MARQUETTE, MI

Controlling Depths

Authorized - 25 ft basin.
Actual - Authorized depths are maintained.

Loading/Unloading Facilities

1 active coal dock--self-unloaders only.
6 inactive coal, ore, petroleum, and other docks.
Several small fish wharves.

Commercial Navigation Season

Begins - Earliest 7 April, latest 5 May.
Ends - Earliest 14 November, latest 13 December.

Authority for Maintenance

The existing project was authorized by the 1867, 1888, 1910, 1955, and 1960 Rivers and Harbors Acts. Project is complete.

Vessel Length and Beam Limitation

Vessel length 675 ft, depth 27 ft; 700 ft length, 22 ft depth (14).

TACONITE HARBOR, MN

Controlling Depths

Actual - 27 to over 50 ft entrance channel and harbor, 29 ft exit channel.

Loading/Unloading Facilities

1 ore loading dock
1 coal unloading dock
1 liquid cargo dock

Commercial Navigation Season

Begins - Earliest 2 April, latest 29 April.
Ends - Earliest 7 December, latest 1 January.

Authority for Maintenance

Taconite is a private harbor entirely maintained and owned by the Erie Mining Company.

Vessel Length and Beam Limitations

None (16).

SILVER BAY, MN

Controlling Depths

Actual - 30 ft in the basin, 28 ft alongside dock.

Loading/Unloading Facilities

3,670 ft long dock inland side of basin containing 1 ore loading dock, 1 coal unloading dock, and 1 fuel oil unloading dock.

Commercial Navigation Season

Begins - Earliest 1 April, latest 23 April.
Ends - Earliest 9 December, latest 25 December.

Authority for Maintenance

Silver Bay is a private harbor entirely owned and maintained by the Reserve Mining Company.

Vessel Length and Beam Limitations

None (16).

ASHLAND, WI

Controlling Depths

Authorized - 20 to 21 ft west channel, 25 to 27 ft east basin.
Actual - Authorized depth maintained except 16 ft west section of west channel.

Loading/Unloading Facilities

Self-unloaders only.
3 coal, ore, limestone docks and wharves.
Owned by City of Ashland.

Commercial Navigation Season

Begins - Earliest 13 April, latest 3 May.
Ends - Earliest 14 November, latest 17 December.

Authority for Maintenance

The existing project was authorized by the 1886, 1888, 1899, 1900, 1917, 1930, 1935, 1945, and 1960 Rivers and Harbors Acts. Project is considered complete.

Vessel Length and Beam Limitations

Vessel length 1,000 ft (14).

6.10.2 Lake Michigan Harbors

GREEN BAY, WI

Controlling Depths

Authorized - 26 ft and 24 ft sections entrance channel, 24 ft lower Fox River and turning basin, 20 ft middle turning basin, 18 ft upper Fox River and turning basin.
Actual - Authorized depths are maintained.

Loading/Unloading Facilities

16 wharves total containing 37 docks.
3 coal docks are self-unloaders only.
2 stone, sand, and dry bulk cargo docks are self-unloaders only.
General cargo docks - loading/unloading.
Liquid cargo docks - loading/unloading.

Commercial Navigation Season

Begins - Average 15 April, earliest 30 March.
Ends - Average 15 December, latest 3 January.

Authority for Maintenance

The existing project was authorized by the 1866, 1892, 1910, 1917, 1925, 1935, 1937, 1945, and 1962 Rivers and Harbors Acts. Project is complete.

Planned Harbor Development

A supplemental design memorandum is being prepared that would involve deepening the Fox River an additional 4 feet for 1/4 mile immediately upstream of the project completed in 1973.

Vessel Length and Beam Limitations

Dock length 1,100 feet (14).

MILWAUKEE, WI

Controlling Depths

Authorized - 30 ft approach channel, 28 ft south outer harbor and entrance channel, 21 ft north outer harbor, 27 ft inner harbor (lower Kinnickinnic River, lower Milwaukee River, lower Menomonee River, and Kinnickinnic Basin), 21 ft upper rivers sections.
Actual - Authorized depths are maintained.

Loading/Unloading Facilities

57 wharves total.
4 coal docks--self-unloaders only.
Stone, sand, and dry bulk dock--no loading, self-unloaders only.
General cargo docks.
Liquid cargo docks--loading/unloading.

Commercial Navigation Season

Salties - Begins 1 April, ends 15 December.
Interlake - 11 months.
Railroad car ferries and oil tankers - year-round.

Authority for Maintenance

The existing project was authorized by the 1852, 1883, 1907, 1922, 1935, 1945, 1960, and 1962 Rivers and Harbors Acts. The project is considered complete. The uncompleted portion, dredging Milwaukee River (upper section), was deauthorized in 1977.

Vessel Length and Beam Limitations

None (28).

CHICAGO HARBOR, IL

Controlling Depths

Authorized - 29 ft approach channel, 28 ft maneuver area and channel, 21 ft entrance channel, 21 ft inner basin.
Actual - Authorized depths are maintained.

Loading/Unloading Facilities

No loading equipment.
7 general cargo docks.
City of Chicago owns 5 docks - 4 are for commercial purposes.

Commercial Navigation Season

Lakers - Begins 15 March, ends 25 December.
Salties - Begins 1 April, ends 15 December*.

Authority for Maintenance

The existing project was authorized by the 1870, 1880, 1899, 1912, 1919, 1931, 1945, and 1962 Rivers and Harbors Acts. Project is complete.

Vessel Length and Beam Limitations

None (28).

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* Salties arrive at Chicago later and must leave earlier because of ice.

CHICAGO RIVER, IL

Controlling Depths

Authorized - 21 ft main channel.
Actual - Authorized depths are maintained.

Loading/Unloading Facilities

23 docks.
Facilities handle sand, gravel, coal, salt, cement, and petroleum products.

Commercial Navigation Season

Lakers - Begins 15 March, ends 25 December.
Salties - Begins 1 April, ends 15 December.

Authority for Maintenance

The existing project was authorized by the 1899, 1902, 1907, 1919, and 1946 Rivers and Harbors Acts. The project is complete except for dredging a 9 ft channel in the upper reaches of the river. This portion is in the deferred for restudy category.

Vessel Length and Beam Limitations

Vessel length, 600 feet (14).

CALUMET HARBOR/LAKE CALUMET, IN-IL

Controlling Depths

Authorized - 29 ft approach channel, 28 ft outer harbor, 27 ft river entrance, 27/28* ft for river turning basin 3, 27 ft elsewhere (turning basins, etc).

Actual - Authorized depths are maintained except for uncompleted work outlined in "Authority for Maintenance".

Loading/Unloading Facilities

Calumet River and outer harbor - 33 docks for handling various cargos.

Lake Calumet - 3 transit sleds, 2 grain elevators, and 3 private cargo docks.

Commercial Navigation Season

Year-round.

Winter traffic is restricted to tug-barges.

Authority for Maintenance

The existing project was authorized by the 1899, 1902, 1905, 1910, 1922, 1935, 1945, 1960, 1962, and 1965 Rivers and Harbors Acts. Project is 79% complete (1978). Work remaining consists of removing hard materials in outer harbor and finishing the straightening, widening, and deepening of isolated sections of the Calumet River.

Vessel Length and Beam Limitations

Dock length 1,840 feet, depth 27 feet (14).

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* First number is for soft material, second number is for hard material.

INDIANA HARBOR, IN

Controlling Depths

Authorized - 29 ft entrance channel, 28 ft outer harbor basin, 27 ft canal entrance channel; 22 ft main canal to turning basin, Calumet River branch, and Lake George Basin.
Actual - 21 ft entrance channel, 17 ft mid-channel, 16 ft turning basin.

Loading/Unloading Facilities

4 ore, limestone, and taconite unloading docks--self-unloaders only.
2 steel mill products barge docks.
13 liquid cargo, miscellaneous commodities, and winter mooring only docks--loading/unloading.

Commercial Navigation Season

Domestic cargo - Begins 15 March, ends 1 February.
Salties - Begins 1 April, ends 5 December.
Barges - year-round.

Authority for Maintenance

The existing project was authorized by the 1910, 1913, 1919, 1922, 1925, 1930, 1932, 1935, 1937, 1960, 1965 Rivers and Harbors Acts. The incomplete portions which called for widening and deepening Lake George Branch and Calumet River Branch, turning basin, and widening Indiana Harbor Canal were deauthorized in 1977. Therefore, the project is considered complete.

Vessel Length and Beam Limitations

None (28).

BURNS WATERWAY, IN

Controlling Depths

Authorized - 30 ft approach channel, 28 ft outer harbor, 27 ft east harbor arm, 27 ft west harbor arm.
Actual - 26 ft outer harbor and east harbor arm, 25 ft west harbor arm.

Loading/Unloading Facilities

3 stone, sand, and dry bulk cargo docks--2 are self-unloaders only.
1 ore unloading dock, 2 general cargo docks.

Commercial Navigation Season

Salties - Ends 12 December.
Lakers (Bethlehem Steel) - Ends late December, early January.
Year-round traffic restricted to tug-barges.

Authority for Maintenance

The existing project was authorized by the 1965 Rivers and Harbors Acts. Dredging was completed in 1970.

Vessel Length and Beam Limitations

None (28).

MUSKEGON, MI

Controlling Depths

Authorized - 29 ft harbor entrance, 28 ft channel entrance, 27 ft channel to Muskegon Lake.
Actual - Authorized depths are maintained.

Loading/Unloading Facilities

2 coal unloading docks--self-unloaders only.
5 sand, stone, and dry bulk cargo docks--3 have no loading equipment, 2 are self-unloaders only.
1 general cargo dock.
1 liquid cargo dock--loading/unloading.

Commercial Navigation Season

Begins 15 April.
Ends 31 December.

Authority for Maintenance

The existing project was authorized by the 1902, 1935, and 1962 Rivers and Harbors Acts. The project is complete.

Vessel Length and Beam Limitations

None (28).

GARY, IN

Controlling Depths

Actual - 27 ft.

Loading/Unloading Facilities

Self-unloaders only.
1 ore unloading dock.
1 stone, sand, and dry bulk cargo dock.

Commercial Navigation Season

U.S. Steel Corporation fleet has operated year-round whenever Soo Locks permits.

Authority for Maintenance

The harbor is entirely owned and maintained by the U.S. Steel Corporation

Vessel Length and Beam Limitations

None (16).

ESCANABA, MI

Controlling Depths

Actual - natural deep water over 30 ft, 24 ft channel and turning basin, 21-28 ft alongside docks.

Vessel Restrictions

Conditions are such that the largest lake vessels have free access and only very minor dredging is required alongside the docks.

Loading/Unloading Facilities

1 ore loading dock.
2 coal unloading docks--self-unloaders only.
3 petroleum and jet fuel docks.

Commercial Navigation Season

Year-round.

Authority for Maintenance

Docks are privately owned and maintained.

Vessel Length and Beam Limitations

None (16).

GRAND HAVEN, MI

Controlling Depths

Authorized - 23 ft entrance channel, 21 ft river and turning basin and Spring Lake Channel, 8 ft upper Grand River Channel.
Actual - Authorized depths are maintained except for miscellaneous shoaling in turning basins.

Vessel Restrictions

Not adapted for anchorage.

Loading/Unloading Facilities

Several wharves -- coal, limestone, sand, gravel, and petroleum.
Self-unloaders only.

Commercial Navigation Season

Begins - Earliest 4 March, latest 7 April.
Ends - Earliest 11 November, latest 29 December.

Authority for Maintenance

The existing project was authorized by the 1866, 1880, 1890, 1892, 1930, 1937, and 1945 Rivers and Harbors Acts. The project is considered complete.

Planned Harbor Development

The plan which appears most feasible for modification of the existing Federal project at Grand Haven Harbor consists of deepening the existing Grand Haven Harbor channel to a controlling project depth of 27 ft and providing a new turning channel. The plan would require the relocation of one telephone cable crossing.

Vessel Length and Beam Limitations

Coal 437 feet, depth 21 feet (14).

LUDINGTON, MI

Controlling Depths

Authorized - 18 ft exterior basin, 30 ft outer entrance channel, 29 ft channel through exterior basin to Pere Marquette Lake.
Actual - 26 ft outer entrance channel, 20 ft in channel between piers to Pere Marquette Lake.

Loading/Unloading Facilities

1 coal unloading dock--self-unloaders only.
4 sand, stone, and dry bulk cargo docks--3 are self-unloaders only with no loading equipment.
2 liquid cargo docks--loading/unloading.

Commercial Navigation Season

Begins - 2 April.
Ends - 31 December.

Authority for Maintenance

The existing project is authorized by the 1867, 1899, 1907, and 1970 Rivers and Harbors Acts. The latest modification (1970), which calls for deepening channels and breakwater openings, is 71% complete (1979). Prior projects were finished in 1918.

Vessel Length and Beam Limitations

Coal dock length 1,137 feet, depth 24 feet; stone dock length 1,300 feet, depth 24 feet (14).

BUFFINGTON, IN

Controlling Depths

Actual - 26 ft harbor basin.

Loading/Unloading Facilities

1 stone, sand, and dry bulk cargo dock--self-unloaders only.

Commercial Navigation Season

Begins - Earliest 29 March, latest 26 April.
Ends - Earliest 24 November, latest 29 December.

Authority for Maintenance

Buffington is entirely owned and maintained by the Universal Cement Division of U.S. Steel Corporation.

Vessel Length and Beam Limitations

None (14).

PORT INLAND, MI

Controlling Depths

Actual - 25 ft entrance channel.

Loading/Unloading Facilities

1 sand, stone, and dry bulk cargo dock--self-unloaders only.

Commercial Navigation Season

Begins - mid-March.
Ends - mid-December.

Authority for Maintenance

Port Inland is entirely owned and maintained by Inland Lime and Stone Company.

Vessel Length and Beam Limitations

680 feet maximum overall length, depth 25 feet (14).

PORT WASHINGTON, WI

Controlling Depths

Authorized - 21 ft entrance channel and outer basin, 18 ft inner basins.
Actual - Authorized depths are maintained.

Loading/Unloading Facilities

1 coal unloading dock.

Commercial Navigation Season

Year-round.

Authority for Maintenance

The existing project was authorized by the 1870, 1876, 1935, and 1958 Rivers and Harbors Acts. The portion which called for extending and raising north breakwater was deauthorized in 1977.

Vessel Length and Beam Limitations

Dock length 1,100 feet (14).

6.10.3 Lake Huron Harbors

SAGINAW RIVER, MI

Controlling Depths

Authorized - 27 ft entrance, 26 ft channel at river mouth decreasing to 16.5 ft at upper project limit in river at 19 mile point; five turning basins, 25 ft, 22 ft, 20 ft, 20 ft, and 15 ft.
Actual - 24 ft channel decreasing to 8 ft at upper project limit.

Loading/Unloading Facilities

2 grain elevators.
11 stone, sand, and dry bulk cargo docks--9 are self-unloaders only.

Commercial Navigation Season

Begins - Earliest 24 March, latest 13 April.
Ends - Earliest 16 December, latest 28 December.

Authority for Maintenance

The existing project was authorized by the 1910, 1930, 1937, 1938, 1954, 1962, and 1965 Rivers and Harbors Acts. Project is complete except for channel section of the 1962 Act which is pending modification.

Vessel Length and Beam Limitations

Stone, maximum length overall 650 feet, depth 22 feet (14).

ST. CLAIR RIVER HARBORS, MI

St. Clair, Marysville, Port Huron

Controlling Depths

Authorized - 27 to 28 ft in St. Clair, 30 ft at river entrance. The depths are designed for 25.5 ft draft at LWD. For a more detailed coverage please see St. Clair River section.
Actual - Authorized depths are maintained.

Loading/Unloading Facilities

St. Clair, MI -- coal receiving dock.
Marysville, MI -- coal receiving dock.
Port Huron, MI -- several stone, oil, and general cargo docks.

Commercial Navigation Season

Year-round with CG icebreaker escort when needed.

Authority for Maintenance

The existing project was authorized by the 1892, 1930, 1945, 1946, and 1956 Rivers and Harbors Acts. Project is considered complete except for construction of submerged rock sills and north channel entrance improvements.

Vessel Length and Beam Limitations

St. Clair -- coal, maximum length 970 feet, depth at dock 22 feet (14).

Marysville -- coal, maximum length 450 feet, depth at dock 21 feet (14).

Port Huron -- stone, maximum length 980 feet, depth at dock 20 feet (14).

PORT OF DETROIT, MI

Detroit Harbor, Rouge River, Ecorse, Wyandotte, Riverview

Controlling Depths

Authorized - 27 to 29 ft Detroit River; Rouge River, 25 ft at Short Cut Canal and mouth decreasing to 21 ft turning basin, 13 ft beyond turning basin to upper project limit; 25-17 ft Rouge River from Detroit River to junction of Short Cut Canal and Rouge River.
Actual - Authorized depths are maintained except for the Short Cut Canal-Rouge River junction basin which is 19 ft, and the 13 ft portion which is deauthorized.

Loading/Unloading Facilities

Total of 92 piers, wharves, and docks.
Various cargo handled -- general cargo, petroleum products, cement and cement clinker, coal, coal tar, iron ore and iron ore pellets, limestone, newsprint, salt, and sand. Miscellaneous cargos handled include asphalt, coke and steel mill products, gypsum rock, bulk pitch, steel ignots, scrap metal, alkali and soda ash, and liquid alkali products.

Commercial Navigation Season

Year-round.

Authority for Maintenance

The existing project for the Detroit River by the 1902, 1905, 1907, 1910, 1913, 1919, 1930, 1935, 1937, 1945, 1946, 1950, 1956, 1960, and 1968 River and Harbors Acts. Trenton Channel is complete. Latest modification is complete except for compensating works to maintain water levels.

The Rouge River project was authorized by 1917, 1935, 1958, and 1962 Rivers and Harbors Acts. All pre-1962 work has been completed or deauthorized such as the 13 ft upper river section. The work of the 1962 modification that calls for modified limits of the Short Cut Canal has been classified inactive.

Vessel Length and Beam Limitations

None (28).

ALPENA, MI

Controlling Depths

Authorized - 24 ft channel to river entrance, 23 ft river channel decreasing to an 18.5 ft channel for 1,600 ft, 15 ft upper turning basin, 19 ft turning basin at mouth of river.
Actual - 20 ft lake channel, 18 ft river channel, 13 ft upper turning basin.

Loading/Unloading Facilities

2 coal unloading docks--self-unloaders only.
5 stone, sand, and dry bulk cargo docks--3 have no loading equipment.
1 liquid cargo unloading dock.

Commercial Navigation Season

Begins - Earliest 15 March, latest 17 April.
Ends - Earliest 21 November, latest 20 December.

Authority for Maintenance

The existing project was authorized by the 1890, 1919, 1922, 1935, and 1965 Rivers and Harbors Acts. The latest modification (1965) which called for channel deepening, breakwater, and turning basin construction was reclassified inactive in 1969.

Vessel Length and Beam Limitations

Coal, maximum length 621 feet, depth at dock 20 feet; maximum length 572 feet, depth at dock 23 feet (14).

Stone, maximum length 650 feet, depth at dock 18 feet; maximum length 604 feet, depth at dock 27 feet (14).

STONEPORT, MI

Controlling Depths

Actual - 25 ft.

Loading/Unloading Facilities

1 stone, sand, and dry bulk cargo dock.
1 5,500 tons/hr conveyor.

Commercial Navigation Season

Begins - 26 March.
Ends - 1 January.

Authority for Maintenance

Stoneport is entirely owned and maintained by Presque Isle Corporation.

Vessel Length and Beam Limitations

Maximum vessel length 826 feet, depth at dock 26 feet (14).

DRUMMOND ISLAND, MI

Controlling Depth

Actual - 30 ft to and from Lake Huron, 27 ft to and from Lake Superior (St. Marys River), 23 ft at dock.

Loading/Unloading Facilities

1 stone, sand, and dry bulk cargo dock.
1 liquid cargo dock--unloading.

Commercial Navigation Season

Ends 15 December.

Authority for Maintenance

Drummond Island Port consists of one 800 ft long wharf which is owned and maintained by Drummond Dolomite, Inc.

Vessel Length and Beam Limitations

Maximum vessel length 690 feet, maximum beam 78 feet; depth at dock 23.5 feet (14).

PORT DOLOMITE, MI

Controlling Depths

Actual - 29 ft alongside dock, 27 ft channel.

Loading/Unloading Facilities

1 stone, sand, and dry bulk cargo dock--self-unloaders only.

Commercial Navigation Season

Begins - 1 April
Ends - 15 December.

Authority for Maintenance

Port Dolomite is entirely owned and maintained by the Michigan Limestone Division of U.S. Steel Corporation.

Vessel Length and Beam Limitations

Dock length 600 feet, depth at dock 27 feet (14).

6.10.4 Lake Erie Harbors

TOLEDO, OH

Controlling Depths

Authorized - 28 ft (18 mile long) entrance channel to river mouth, 27 ft river channel decreasing to 25 ft at upper project limit (mile 7); turning basins-20, 27, and 18 ft, 28 ft sailing course from entrance channel to East Outer Channel Detroit River.

Loading/Unloading Facilities

41 piers, wharves, and docks.
Facilities can handle cement, liquid sugar, newsprint, coal, general and containerized cargo in foreign trade, grain, iron ore, coal, coke, limestone, pig iron, petroleum products, asphalt, salt, sand, stone, and gravel.

Commercial Navigation Season

Begins - Earliest 7 March, latest 4 April.
Ends - Earliest 8 December, latest 21 December.

Authority for Maintenance

The existing project was authorized by the 1899, 1910, 1935, 1950, 1954, 1958, and 1960 Rivers and Harbors Acts. Project is complete.

Vessel Length and Beam Limitations

None (28).

SANDUSKY, OH

Controlling Depths

Authorized - 26 ft Mosley entrance channel, 25 ft upper Bay Channel and upper Straight Channel, 21 ft lower Straight Channel, 22 ft dock channel, 24 ft lower Bay Channel and turning basin.
Actual - Authorized depths are maintained.
No Federal dredging within 50 ft of docks.

Loading/Unloading Facilities

14 piers and wharves, including--1 coal loading and 1 stone, sand, and dry bulk cargo dock, self-unloaders only.

Commercial Navigation Season

Begins - Earliest 9 March, latest 13 April.
Ends - Earliest 17 November, latest 18 December.

Authority for Maintenance

The existing project was authorized by the 1899, 1902, 1919, 1927, 1935, 1945, and 1960 Rivers and Harbors Acts. Project is complete.

Vessel Length and Beam Limitations

None (19).

HURON, OH

Controlling Depths

Authorized - 29 ft approach channel, 28/28* ft entrance channel, 27/28* ft river channel, 21/22* ft turning basin.
Actual - 19 ft turning basin.

Loading/Unloading Facilities

1 grain elevator.
1 ore unloading dock.
1 stone, sand, and dry bulk cargo dock, no loading equipment--self-unloaders only.

Commercial Navigation Season

Begins - Earliest 22 March, latest 1 May.
Ends - Earliest 18 November, latest 19 December.

Authority for Maintenance

The existing project was authorized by the 1905, 1919, 1935, and 1962 Rivers and Harbors Acts. The portions which call for deepening lake approach, entrance, and river channels, and enlargement of turning basin remain to be done.

Vessel Length and Beam Limitations

Vessel length 806 feet, beam 75 feet (14).

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* First number is for soft material, second number is for hard material.

LORAIN, OH

Controlling Depths

Authorized - 29/30* ft lake approach, 28/29* ft outer harbor central section, 25/26* ft outer harbor easterly and westerly sections, 16 ft municipal pier approach channel, 27 ft river channel, 3 turning basins--17, 20, and 21 ft.
Actual - 28 ft lake approach, 27 ft outer harbor central section, 9 to 16 ft lower turning basin, 18 ft upper basins with 10 ft shoaling along north limits.

Loading/Unloading Facilities

2 ore unloading docks--1 self-unloader only.
6 stone, sand, and dry bulk cargo docks--4 are self-unloaders only.
1 liquid cargo unloading dock.

Commercial Navigation Season

Begins - Earliest 15 March, latest 7 April.
Ends - Earliest 13 December, latest 31 December.

Authority for Maintenance

The existing project was authorized by the 1899, 1907, 1910, 1917, 1930, 1935, 1945, 1960, and 1965 Rivers and Harbors Acts. Remaining work which calls for widening remaining portion at bends in the river, bank stabilization, and dredging adjacent to east and west piers has been classified as deferred.

Planned Harbor Development

The present plans for improvement at Lorain Harbor, OH consists of modifications to the Outer Harbor to allow for safe and efficient navigation of 1,000 ft vessels to a lake front transshipment facility. The iron ore, which is the primary commodity, could then be transshipped upriver either by rail, conveyor, truck, or special purpose vessel. The modifications necessary to implement this plan are as follows:

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* First number is for soft material, second number is for hard material.

a. Increased depth in outer harbor;
b. Removal of approximately 600 ft of the north end of the East Breakwater;
c. Addition of approximately 600 ft to the south end of the Outer Breakwater;
d. Construction of a lakefront transshipment facility; and,
3. Construction of facilities necessary to accommodate whichever of the four transshipment modes is selected.

Vessel Length and Beam Limitations

Ore, no length limitations (14).

CLEVELAND, OH

Controlling Depths

Authorized - 29 ft lake approach channel, 28 ft West Basin and entrance channel to Cuyahoga River, 25-28 ft East Basin, 25 ft Airport Range, 27 ft mouth of Cuyahoga River for approximately 1/4 mile, 27 ft from 1/4 mile point to junction with Old River thence to upper limit on Old River, 28 ft Cuyahoga River to upper limit, 18 ft turning basin mile 4.8 Cuyahoga River.
Actual - 28 ft East Basin, 21-23 ft Old River.

Loading/Unloading Facilities

72 piers and wharves.
Facilities can handle cement, fish, general and containerized cargo in foreign trade, grain, iron ore, limestone, sand, gravel, salt, marl, coke breeze, pig iron, sulphur, linseed oil, latex, chemicals, fluorspar, dolomite, steel products, ferrous scrap, petroleum products, asphalt, and petrochemicals.

Commercial Navigation Season

Begins - Earliest 21 March, latest 8 April.
Ends - Earliest 5 December, latest 20 December.

Authority for Maintenance

The existing project was authorized by the 1875, 1886, 1888, 1896, 1899, 1902, 1910, 1916, 1917, 1935, 1937, 1945, 1946, 1958, 1960, and 1962 Rivers and Harbors Acts, and 1976 Water Resources Development Act. Work remaining is portions of the 1976, 1960, 1958, and 1946 acts. Portions which call for deepening the widening Old River have been classified deferred. The portion which calls for widening Cuyahoga River has been classified inactive.

Planned Harbor Development

The Federal harbor facilities at Cleveland, OH are being studied to determine if improvements to the project are economically justified and environmentally acceptable. The study has been divided into four components as follows:

a. Operation of 1,000 ft vessels in the Lakefront Harbor (the Lakefront Harbor has historically accommodated Seaway-size vessels up to 730 ft x 75 ft). Improvements being investigated include: a) an "all-weather" east entrance channel; b) a "fair-weather" west entrance which consists of deepening and widening the west entrance, removal of a portion of the spur breakwaters and mitigation measures to compensate for increased wave activity in the harbor as a result of the spur breakwater removal; and c) an "all-weather" west entrance which consists of deepening the west entrance and providing additional breakwater-protected entrance channel length.

b. Deepening of the Cuyahoga River Navigation Channel from 23 ft below LWD (existing conditions) up to 27 ft, to make the navigation channel compatible with the Great Lakes System draft of 25.5 ft.

c. An investigation to determine the feasibility of reducing vessel congestion on the Cuyahoga River and Old River Navigation Channels by modifying the river (widening of bends, bankcuts, bridge modifications, and turnouts, etc.) at historically constricted locations.

d. A re-examination of authorized, but uncompleted, improvements on the Old River (bridge replacement, several bank cuts and deepening to 27 ft) which would permit vessels up to 730 ft in length and 75 ft in beam to navigate the Old River Navigation Channel fully loaded.

Vessel Length and Beam Limitations

Ore - 730 feet long, 76 foot beam.

Stone - 666 feet long, 72 foot beam, depth at dock 23 feet (14).

ASHTABULA, OH

Controlling Depths

Authorized - 29/30* ft entrance channel to a point inside breakwaters, 28/29* ft section parallel to west breakwater and area inside east breakwater, 27/28* ft Ashtabula River mouth and channel to 2,000 ft point, 18 ft decreasing to 16 ft at upper river limit, 22/23* ft turning area in front of inner breakwater.
Actual - Authorized depths are maintained.

Loading/Unloading Facilities

16 piers and wharves.
3 are ore unloading docks--2 self-unloaders only.
1 is coal unloading dock.
5 are stone, sand, and dry bulk cargo docks--4 self-unloaders only.
1 is general cargo dock.

Commercial Navigation Season

Begins - Earliest 17 March, latest 12 April.
Ends - Earliest 3 December, latest 31 December.

Authority for Maintenance

The existing project was authorized by the 1896, 1905, 1910, 1919, 1935, 1937, 1945, 1954, 1960, and 1965 Rivers and Harbors Acts. Project is complete.

Vessel Length and Beam Limitations

None (14).

* First number is for soft material, second number [illegible] material.

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CONNEAUT, OH

Controlling Depths

Authorized - 28/29* ft easterly outer harbor, 22/23* ft westerly outer harbor, 27/28* ft inner harbor, 8 ft access channel to city dock.
Actual - Authorized depths are maintained.

Loading/Unloading Facilities

1 ore unloading dock.
2 stone, sand, and dry bulk cargo docks--1 self-unloader only.

Commercial Navigation Season

Begins - 14 April.
Ends - 13 January.

Authority for Maintenance

The existing project was authorized by the 1910, 1917, 1935, 1962, and 1966 Rivers and Harbors Acts. The portions for commercial navigation are complete.

Vessel Length and Beam Limitations

None (14).

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* First number is for soft material, second number is for hard material.

ERIE, PA

Controlling Depths

Authorized - 29 ft entrance channel, 28/29* ft harbor basin, 27/28* ft approach to turning basin, 21 ft Erie turning basin, 18 ft Harbor turning basin.
Actual - Authorized depths are maintained.

Loading/Unloading Facilities

4 stone, sand, and dry bulk cargo docks--self-unloaders only.
1 general cargo dock.
2 liquid cargo unloading docks.

Commercial Navigation Season

Begins - Earliest 10 March, latest 19 April.
Ends - Earliest 9 December, latest 23 December.

Authority for Maintenance

The existing project was authorized by the 1824, 1899, 1910, 1922, 1935, 1945, 1954, 1960, and 1962 Rivers and Harbors Acts. The portion which called for deepening an approach channel to Penn Central Company coal docks to 23 ft was deauthorized in 1977. The portion which called for deepening strips adjacent to the piers on either side of the entrance channel is classified as deferred.

Vessel Length and Beam Limitations

Dock length 1,230 feet, depth at dock 25 feet (14).

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* First number is for soft material, second number is for hard material.

PORT OF BUFFALO, NY

Niagara River, Buffalo River

Controlling Depths

Authorized - 25/26* ft north entrance channel, 29-30 ft south entrance channel, 28 ft southerly outer harbor, 27 ft middle outer harbor, 23 ft portion of middle outer harbor, 23 ft northerly outer harbor, 22/23* ft Buffalo River, 22/23* ft Buffalo River entrance channel, Buffalo River, and Buffalo River canal, 21 ft Black Rock channel entrance, 21 ft Black Rock channel, 16 to 21 ft Tonawanda Harbor and turning basin, 16 ft Tonawanda Creek channel, 12 ft Niagara River channel.

Actual - For sections not under project - 27 ft Lackawanna Canal, 20 ft Union Canal, 14 ft Tonawanda Harbor, 12 ft Tonawanda Creek channel, Niagara River channel not maintained.

Loading/Unloading Facilities

5 grain elevators.
3 ore unloading docks--1 self-unloader only.
14 stone, sand, and dry bulk cargo docks--11 are self-unloaders only, 9 no loading equipment.
2 general cargo docks.
3 liquid cargo docks--loading/unloading.
Black Rock Channel and Niagara River - mostly barge terminals and small craft wharves.

Commercial Navigation Season

Begins - Earliest 20 March, latest 28 April.
Ends - Earliest 17 December, latest 31 December.

Authority for Maintenance

The existing Buffalo Harbor project was authorized by the 1826, 1866, 1874, 1896, 1900, 1902, 1907, 1909, 1910, 1912, 1919, 1927, 1930, 1935, 1945, 1960, and 1962 Rivers and Harbors Acts. The project is complete.

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* First number is for soft material, second number is for hard material.

The Black Rock channel and Tonawanda Harbor project was authorized by the 1888, 1902, 1905, 1916, 1919, 1922, 1925, 1934, 1935, 1945, and 1954 Rivers and Harbors Acts. Project is complete except for deepening Tonawanda Harbor which has been classified deferred.

The Black Rock ship lock with 625 ft available length, 68 ft clear width, and 21.6 ft depth at sills was finished in 1914.

The Niagara River channel project was authorized by the 1912 and 1930 Rivers and Harbors Acts. The project is complete.

Planned Harbor Development

The improvement alternatives presently under study for the Buffalo Harbor portion of the larger Port of Buffalo are:

a. Deepening of the Buffalo River, the Buffalo Ship Canal, and the North Entrance channel to accommodate larger vessels.

b. Outer Buffalo Harbor improvements to support various bulk transshipment schemes for moving grain, iron ore, and limestone materials to upriver industry.

c. An outer Buffalo Harbor improvement plan to redesign the present south entrance channel for safe all-weather operation of 1,000 ft vessels.

Vessel Length and Beam Limitations

Length 730 feet, beam 76 feet (28).

MONROE, MI

Controlling Depths

Authorized - 21 ft entrance channel and lower portion of Raisin River to turning basin, 18 ft turning basin, 9 ft upper river to project limit.
Actual - 19 ft entrance channel, 14 ft decreasing to 10 ft channel edges in the turning basin.

Loading/Unloading Facilities

2 coal unloading docks--self-unloaders only.
1 stone, sand, and dry bulk cargo dock--no loading equipment.

Commercial Navigation Season

Begins - Earliest 7 March, latest 29 April.
Ends - Earliest 8 November, latest 31 December.

Authority for Maintenance

The existing project was authorized by the 1835, 1930, and 1932 Rivers and Harbors Acts. Project was considered complete in 1936.

Planned Harbor Development

The proposed modifications to Monroe Harbor, Michigan, includes deepening of River Raisin portion of the channel to 27 ft, widening to 500 ft and deepening to 28 ft the portion of the channel in Lake Erie, providing a new turning basin near the shore and south of the channel to permit turning of vessels up to 1100 ft long, and constructing a confined disposal area for the polluted dredge material, which would also provide protection to wetlands in Plum Creek Bay.

Vessel Length and Beam Limitations

Maximum vessel length 730 feet, maximum beam 76 feet (16).

FAIRPORT, OH

Controlling Depths

Authorized - 29 ft entrance channel, 28 ft middle outer harbor basin, 25/26* ft easterly and westerly outer harbor sections, 27/28* ft Grand River, and 21 ft turning basin.
Actual - 21 ft entrance channel and middle outer harbor, 21 ft Grand River, 15 ft turning basin, 9.5 - 25 ft westerly outer harbor, 12-24 ft easterly outer harbor.

Loading/Unloading Facilities

7 stone, sand, and dry bulk cargo docks--6 self-unloaders only, 6 no loading equipment.

Commercial Navigation Season

Begins - Earliest 13 March, latest 19 April.
Ends - Earliest 2 December, latest 24 December.

Authority for Maintenance

The existing project was authorized by the 1825, 1896, 1905, 1919, 1927, 1930, 1935, 1937, 1946, and 1960 Rivers and Harbors Acts and the 1965 Flood Control Act. The project is 35% complete and the 1960 modification which calls for deepening to present project depths is classified inactive.

Vessel Length and Beam Limitations

Maximum vessel length, 650 feet (16).

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* First number is for soft material, second number is for hard material.

6.10.5 Lake Ontario Harbors

OSWEGO, NY

Controlling Depths

Authorized - 27 ft approach channel, 25 ft central outer harbor, 21 ft east and west harbor sections, 24 ft Oswego River entrance channel, 21 ft Oswego River to upper project limit.
Actual - Authorized depths are maintained.

Loading/Unloading Facilities

1 grain elevator.
2 stone, sand, and dry bulk cargo docks--no loading equipment.
2 general cargo docks.
2 liquid cargo docks.

Commercial Navigation Season

Begins - Earliest 17 April, latest 29 April.
Ends - Earliest 26 November, latest 3 December.

Authority for Maintenance

The existing project was authorized by the 1870, 1907, 1930, 1935, 1940, 1948, 1954, and 1962 Rivers and Harbors Acts. The project is 73% complete and the portion which calls for deepening to project depth two sections of the east and west harbor basins is classified as inactive.

Vessel Length and Beam Limitations

Seaway limitations, length 730 feet, beam 76 feet (16).

ROCHESTER, NY

Controlling Depths

Authorized - 24 ft approach channel, 23 ft entrance channel and lower turning basin, 21 ft Genessee River and upper turning basin.
Actual - 20 ft approach channel, 21 ft entrance channel, 19 ft turning basin with east edge shoaled to 7 ft, 17 ft upper turning basin decreasing to 7 ft at west limit with shoaling to bare in northwest portion of basin, 19 ft river to upstream project limit.

Loading/Unloading Facilities

1 stone, sand, and dry bulk cargo dock--no loading equipment.

Commercial Navigation Season

Begins - Earliest 16 March, latest 17 April.
Ends - Earliest 18 November, latest 16 December.

Authority for Maintenance

The existing project was authorized by the 1829, 1882, 1910, 1935, 1945, and 1960 Rivers and Harbors Acts. Project is complete.

Vessel Length and Beam Limitations

Maximum vessel length 450 feet, beam 55 feet; depth at dock 21 feet (14).

OGDENSBURG, NY

Controlling Depths

Authorized - 19 ft all channels, 21 ft lower basin.
Actual - 28 ft entrance channel, 27 ft beside 600 ft berth, 17 ft near grain elevator.

Loading/Unloading Facilities

2 stone, sand, and dry bulk cargo docks--self-unloaders only, no loading equipment.
1 general cargo dock.
5 liquid cargo dock--unloading only.

Authority for Maintenance

The existing project was authorized by the 1910, 1919, and 1935 Rivers and Harbors Acts. Portion which calls for removal of hard shoal materials from lower basin is classified inactive. Otherwise, the project is complete.

Vessel Length and Beam Limitations

Stone dock length 1,590 feet, depth at dock 16 feet (14); dock length 1,000 feet, depth at dock 18 feet (14).

6.11 Summary of Physical Limitations

The capacity of the GL/SLS system is constrained by the physical limitations of channels, locks, and harbors.

6.11.1 Channel Restrictions

CONTROLLING DEPTH

- St. Marys River - 27 feet
- St. Clair River - Detroit River - 27 feet
- Welland Canal - 27 feet
- St. Lawrence River - 27 feet

Overall, at LWD the system is limited to ships with a draft of 25.5 feet in the Soo Locks, St. Marys River, St. Clair River, and the Detroit River; a 26 foot draft is permitted in the Welland Canal and St. Lawrence River Locks.

NAVIGATION

- St. Marys River
  - Three sharp turns occur in the channel that should be altered if the length of ships is to exceed 1000 feet.
  - A precise electronic navigation system would be required for full season navigation.
  - Icebreaker assistance would be required for full season navigation.
- St. Clair River - Detroit River
  - Three sections are limited to one-way traffic.
  - A precise electronic navigation system would be required for full season navigation.
  - Icebreaker assistance is required for full season navigation.

• Welland Canal

- One short section is limited to one-way traffic.

- A precise electronic navigation system would be required for full season navigation.

- Icebreaker assistance is required for full season navigation.

• St. Lawrence River

- Strong currents crossing the channel present a hazard to navigation at four locations.

- A precise electronic navigation system is required for full season navigation.

- Icebreaker assistance is required for full season navigation.

6.11.2 Locks Restrictions

SHIP SIZE (feet)

	LENGTH	BEAM	DRAFT
Soo	1100	105	30.5*
Welland	730	76	26
St. Lawrence	730	76	26

* LWD draft at Poe Lock allowing 1.5 ft clearance at the sill.

6.11.3 Locks Maintenance Problems

Interviews with engineering and maintenance directors indicate that the locks are basically in a good state of repair at all locations. Historically, there has been adequate time to perform both preventative and corrective maintenance during the time that the locks are closed in the winter. Routine maintenance is often required for lock walls. Some cement deterioration occurs and repairs are made when the locks are closed. Winter navigation will provide a short-term increase in lockwall deterioration, however, normal maintenance routines can be adjusted to minimize anticipated problems. Lock gates and operating machinery

are also repaired or replaced as required. Winter navigation may also increase mechanical problems, however after locking machinery is modified for winter operations, mechanical maintenance problems are expected to be routine.

Full season operations may require scheduling a warm weather shut-down for maintenance. Scheduling a maintenance shut-down is not entirely adverse, however, because in warm weather the maintenance procedures could be performed more easily, more rapidly, and less expensively. The locks do have some slack periods, even in the summer. If shippers are informed of scheduled maintenance periods well in advance, economic dislocations in the flow of commerce might be minimized.

6.11.4 Engineering and Economic Life

Good maintenance procedures can extend the engineering life of the locks for as long as the locks are required. Lock walls are repaired, lock gates are repaired or replaced, and lock operating machinery is either repaired or replaced.

The economic life of the system is a function of the size of ships that want to use the locks. Locks become obsolete because of ship size. As ships become predominately larger, the smallest locks, the Davis and Sabin, will reach the end of their economic life. Since the MacArthur lock is much larger and serves a large population of relatively new ships, it will reach the end of its economic life much later. If new larger locks are not built, its life will tend to be extended because the ships that can be accommodated by the MacArthur lock will continue to be used.

The question of the economic life of locks can also be viewed inversely. If new larger locks are built, new ships will also be built to the limit of the capacity of these locks, which will accelerate the end of the economic life of the smaller locks. Both the engineering and economic life of a lock is therefore related to other factors, such as the desired capacity of the lock system or the limit of capacity that can be built into the entire navigation system within a reasonable cost or level of engineering difficulty.

6.11.5 Planned Locks Improvements

The Soo Locks and the St. Lawrence River Locks both have current and planned projects to improve the operation of locks in ice conditions. The Welland Canal system has these kinds of projects plus planned operational changes to increase locking capacity.

6.11.6 Long Term Capacity Limitations

There is a trend of decreasing annual lockages and increasing annual tonnage throughput at locks in the GL/SLS. The Soo Locks are not presently constrained, however, an increasing proportion of larger ships in the Great Lakes fleet indicates that the single large lock may become a constraint in the future. The Welland Canal Locks are approaching capacity now and may reach full capacity as early as 1988. Planned physical changes in the system are expected to increase capacity by about 13%. If, in addition to these changes, new operational procedures are initiated, capacity could be increased by about 36%. Additional increases in capacity would require major changes to the system or building an entirely new canal. The St. Lawrence River Locks are not near capacity and are not likely to reach capacity in the near term based on the projected traffic flow. The Welland Canal is currently the section of the system that controls capacity. The St. Lawrencr River Locks are not expected to approach capacity until after a major improvement occurs at the Welland Canal that results in a significant increase of vessel traffic in the lower lakes portion of the GL/SLS.

6.11.7 Alternatives to Alleviate Existing Physical Limitations

- Present System
  - Improve operating procedures at locks.
  - Extend navigation season.
- Future System
  - Change number and size of locks.

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